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Complete List of Authors:	Fu, Wenqi; Harbin Medical University, School of Health Management / Public Health Shi, Jufang; Chinese Academy of Medical Sciences and Peking Union Medical College, Office of Cancer Screening, National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital; zhang, xin; Harbin Medical University, School of Health Management / Public Health Liu, Chengcheng; Chinese Academy of Medical Sciences and Peking Union Medical College, Office of Cancer Screening / National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital Sun, Chengyao; Harbin Medical University, School of Health Management / Public Health Du, Yupeng; Harbin Medical University, School of Health Management / Public Health Wang, Hong; Harbin Medical University, School of Health Management / Public Health Liu, Chaojie; La Trobe University, School of Psychology and Public Health, Lan, Li; Harbin center for disease control and prevention, Institute for Prevention and Control of Chronic Non-communicable Diseases Zhao, Min; Yunnan Provincial Cancer Hospita, Department of Medical Administration Yang, Li; Guangxi Medical University, School of Public Health Bao, Burenbatu; Affiliated Hospital of Inner Mongolia University for Nationalities, Department of Hematology and oncology Cao, Sumei; Sun Yat-sen University Cancer Center, Department of Cancer Prevention Zhang, Yongzhen; Shanxi Provincial Cancer Hospital, Department of Epidemiology Wang, DeBin; Anhui Medical University, Health Management College Li, Ni; Chinese Academy of Medical Sciences and Peking Union Medical College, Office of Cancer Screening / National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital Chen, Wanqing; Chinese Academy of Medical Sciences and Peking Union Medical College, Office of Cancer Screening, National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital Dai, Min; Chinese Academy of Medical Sciences and Peking Union Medical College, Office of Cancer Screening, National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital Liu, Guoxiang; Harbin Medical University, School of Health Management / Public Health

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	He, Jie; Chinese Academy of Medical Sciences and Peking Union Medical College, Office of Cancer Screening, National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital
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Household impoverishment induced by cancer: a multicenter cross-sectional study in China

Wenqi Fu,[a],* Jufang Shi,[b],*　Xin Zhang,[a]　Chengcheng Liu,[b]　Chengyao Sun,[a] Yupeng Du,[a]　Hong Wang,[a]　Chaojie Liu,[c]　Li Lan,[d]　Min Zhao,[e]　Li Yang,[f] Burenbatu Bao,[g]　Sumei Cao,[h]　Yongzhen Zhang,[i]　Debin Wang,[j]　Ni Li,[b] Wanqing Chen,[b]　Min Dai,[b]　Guoxiang Liu,[a]　Jie He[b]

*Contributed equally to this work.

Correspondence to: Guo-Xiang Liu, lgx6301@163.com; Min Dai, daimin2002@hotmail.com; Wan-Qing Chen, chenwq@cicams.ac.cn

[a] School of Health Management / Public Health, Harbin Medical University, Harbin 150081, China

[b] Office of Cancer Screening, National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing 100021, China

[c] School of Psychology and Public Health, La Trobe University, Melbourne VIC 3086, Australia

[d] Institute for Prevention and Control of Chronic Non-communicable Diseases, Harbin Center for Disease Control and Prevention, Harbin, 150056, China

[e] Department of Medical Administration, Yunnan Provincial Cancer Hospital, Kunming 650118, China

[f] School of Public Health, Guangxi Medical University 530021, China

[g] Department of Hematology and oncology, Affiliated Hospital of Inner Mongolia University for Nationalities, Tongliao, 028050, China

[h] Department of Cancer Prevention, Sun Yat-sen University Cancer Center, Guangzhou, 510060, China

[i] Department of Epidemiology, Shanxi Provincial Cancer Hospital, Taiyuan, 030013, China

[j] Health Management College, Anhui Medical University, Hefei 230032, China

1

Abstract

Objectives: This study aimed to determine the incidence and intensity of household impoverishment induced by cancer treatment in China.

Design: Average income and daily consumption per capita of the households and out-of-pocket payments for cancer care were estimated and converted to the US dollar value of 2015. Household impoverishment was determined by comparing per capita daily consumption against the Chinese poverty line (CPL, US$1.2) and the World Bank poverty line (WBPL, US$1.9) for 2015. Both pre-treatment and post-treatment consumptions were calculated assuming that the households would divert daily consumption money to pay for cancer treatments.

Participants: Cancer patients diagnosed initially over the period from 01 January 2015 to 31 December 2016 who had received cancer treatment subsequently. Those with cancers in multiple organs were excluded.

Data sources: A household questionnaire survey was conducted on 2534 cancer patients selected from nine hospitals in seven provinces through a two-stage cluster/convenience sampling strategy.

Principal findings: Cancer treatment is associated with an increase of 7.46% and 15.43% in incidence of household impoverishment according to the CPL and WBPL, respectively. These figures were higher in the rural (13.05% and 26.22%) and the lowest-income (25.39% and 44.49%) populations. The median annual consumption gap per capita underneath the poverty line accumulated by the impoverished households reached US$128 (CPL) or US$212 (WBPL). These amounted to US$43,456,740 (CPL) or US$151,675,531 (WBPL) needed to avoid household impoverishment induced by cancer treatment in China.

Conclusions: The financial burden of cancer treatment imposes a significant risk of household impoverishment despite universal coverage of social health insurance in China. The risk falls disproportionally onto rural and low-income households.

Keywords: Household impoverishment; Cancer; Out-of-pocket payment; China

Strengths and limitations of this study
- This is one of the few studies involving a large sample of cancer patients in China.

2

- Household impoverishment induced by cancer treatment was estimated, including its socioeconomic inequalities.

- National funds required for alleviating household impoverishment induced by cancer treatment were estimated based on new cases of cancer diagnosis.

- Patients with cancers in multiple organs were excluded from the study.

- Data were collected through questionnaire survey, which are subject to recall bias.

Introduction

Cancer causes enormous physical and mental harm on patients and their families [1]. In 2012, 14.1 million new cases of cancer were reported in the world and 8.2 million cancer patients died. These figures surged to 18.1 million and 9.6 million, respectively, in 2018 [2, 3]. A further 75% increase in new cases of cancer over the next two decades is anticipated [4]. China bears the highest burden of cancer, ranking on top of the world not only in absolute numbers and deaths but also in proportion to the population size [4]. It was estimated that 4.3 million new cancer cases were diagnosed and 2.8 million died from cancer in China in 2015 [5]. Cancer has become the leading cause of death in China. The rising trend of cancer shows no sign of containment [6].

The costs of cancer treatment put a great financial stress on cancer patients and their families. According to the Medical Panel Expenditure Survey, the households with a cancer survivor in the US paid on average US$2304 out of pocket (OOP) every year over the period from 2008 to 2016 [7]. The annual OOP spending on metastatic breast cancer treatment in the US during 2004 to 2011 reached US$6642 [8]. A multicenter cross-sectional survey in China over the period from 2012 to 2014 showed that the OOP spending of cancer treatment in the first year averaged at US$4947, which equaled to 57.5% of the average annual household income. About 77.6% of the households with a cancer patient experienced unmanageable financial difficulties [9].

The high cost of cancer treatment has imposed disproportional burdens on the households living with low income. They are more prone to falling into impoverishment as a result of OOP payments for cancer treatment. This has prompted the World Health Organization to call for increasing policy attention addressing the inequality issue through a systems approach [10-12]. A study in Heilongjiang, a province ranked in the middle range of economic development in China, showed that as many as 86% of households with a cancer patient could become impoverished as a result of cancer treatment [13].

3

Health insurance has been widely accepted as an effective strategy to prevent household impoverishment induced by cancer treatment [14]. Although extensive studies have been conducted on the relationship between cancer and poverty [15-18], there is paucity in the literature documenting the situation in low- and middle-income countries [11]. Most low- and middle-income countries cannot afford the same level of insurance entitlements as their high-income counterparts. Internationally, little is known about inequality of household impoverishment resulting from cancer treatment and the role of health insurance in alleviating cancer-induced impoverishment [19].

This study aimed to determine the incidence and intensity of household impoverishment induced by cancer treatment in China. By 2015, more than 95% of Chinese citizens had been covered by social health insurance [20]. However, there have been significant disparities in insurance entitlements across regions, between urban and rural, and across different insurance programs [21]. There are three social health insurance programs subsidized by the government: Basic Medical Insurance for Urban Employees (BMIUE), Basic Medical Insurance for Urban Residents (BMIUR) and rural New Cooperative Medical Scheme (NCMS), all being managed at the municipal or county level with varied funding pools and benefit policies (the latter two started to merge in some regions recently) [20]. There is a shortage of research into the role of these insurance programs in preventing poverty induced by medical care services. The State Council of China made it clear in 2016 that disease-associated poverty would be given priority in the governmental poverty alleviating campaign [22].

Methods

Study design and sites

A multicenter cross-sectional survey was conducted from January 2018 to June 2019 as part of the Cancer Screening Program in Urban China [23]. Geographic regions/provinces were grouped into eastern, central and western in line with the classification of economic development zones by the National Bureau of Statistics. Nine tertiary hospitals were purposively selected from these zones considering cancer patient volumes and completeness of medical records, including Guangdong Cancer Hospital (eastern), Anhui Cancer Hospital, Heilongjiang Cancer Hospital, Shanxi Cancer Hospital (central), Guangxi Cancer Hospital, Yunnan Cancer Hospital, the Regional Cancer Hospital and two city hospitals in Inner Mongolia (western).

Study participants

Cancer patients diagnosed initially over the period from 01 January 2015 to 31 December 2016 were eligible for this study. They had to receive cancer treatment subsequently. Those with cancers in multiple organs were excluded. Lung, breast, colorectum, esophageal, liver, and stomach cancers accounted for 70% of the total sample.

4

Previous studies showed that about 20% households with cancer patients might live in poverty. A sample size of 1600 would allow an estimation of the impoverishment rate with 2% precision as α being set at 0.05 [24]. Given the rapid development of social health insurance in recent years, cancer-induced impoverishment may have dropped significantly. We increased the sample size to 2500, with a minimal of 360 patients being contacted in each participating province. In each province, 720 medical records of cancer patients were randomly extracted for the follow-up survey.

Outcome Indicators

Impoverished households were identified by assessing household consumption against the poverty line [25]. This included regular and repeated expenses to satisfy the essential needs of household members, which only counted the expenses paid out of pocket, not including those subsidized by the government and insurance. A daily household consumption below US$1.2 per capita in the 2015 value was deemed impoverishment according to the State Council of China. Globally, poverty line was set at US$1.90 per capita per day in the 2015 value by the World Bank [26].

The primary outcome indicators included (1) incidence of household impoverishment as a percentage of households living under the poverty line; and (2) intensity of household impoverishment reflected by the gap (measured in US dollars) in household consumption per capita below the poverty line in the impoverished households [25].

The marginal contribution of cancer treatment to household impoverishment was calculated as the difference in incidence of household impoverishment pre- and post-cancer treatment. The expenditure associated with cancer diagnosis and treatment was counted as pre-treatment consumption, which was subsequently deprived from post-treatment consumption. The national scale of impoverishment resulting from cancer treatment was estimated based on the number of new cancer cases reported in 2015 in China.

Data Collection

The follow-up questionnaire survey collected data regarding household income, household consumption, and OOP payments for cancer treatment. The questionnaire was administered through face-to-face interviews over the period from March to December 2018. The survey was coordinated by the National Cancer Center. The interviewers were trained prior to deployment and required to check completeness of the questionnaire before concluding each interview.

In each household, either the patient or her/his primary family caregiver was invited to respond to the questionnaire. Participation was voluntary. Written informed consent was obtained prior to each interview. Of the returned questionnaires, 53% were completed by the patients, compared with 47% by their family caregivers.

The respondents were asked to estimate OOP payments for cancer treatment over a one-year period (two months before and ten months after diagnosis of the cancer). These included OOP payments for hospital diagnosis and treatment and medicines (both

5

prescribed and non-prescribed) purchased from pharmacy retail outlets.

The household income and consumption data covered both 2015 and 2016. Average income and consumption across the two years were calculated to match the cancer treatment cost data due to difficulties to articulate a clear cut-off point for the income and consumption data.

Detailed data regarding household income and consumption items were collected in the questionnaire. The consumption items included foods, clothing, daily necessities, transportation, communication, housing, education, medical care, insurance, and cultural and entertainment activities. Housing costs covered mortgage or rent and utilities such as water, electricity and gas. Capital investments and repairments and other profit generating investment activities were excluded. Leisure traveling costs were also excluded. The income items included salary, return on capital investments, dividends and interests, governmental subsidies and gifts.

Data were double-entered into EpiData 3.1 to ensure accuracy and analyzed using Excel 2010 and IBM SPSS Statistics v22.

Data Analysis

Data about cancer treatment expenditure, household income and consumption were converted to the 2015 value of US dollars (1 USD = 6.2284 Chinese Yuan) for the purpose of assessing impoverishment against the 2015 poverty line set up by the State Council of China and the World Bank.

Pen's Parade graphs were produced to visualize the effect of OOP payments for cancer treatment on household impoverishment. Per capita household consumptions were plotted along the y-axis against the cumulative percentage of households ranked by per capita household consumptions along the x-axis for pre-treatment and post-treatment, respectively. The graphs give a clear indication on the proportion of households living below the poverty line. The area covered by the parade of those below the poverty line indicates the gap in household consumption that needs to fill up to alleviate poverty [25].

Inequality in household impoverishment induced by cancer treatment was assessed by comparing the pre-post treatment differences in incidence of household impoverishment in patients with different household incomes and insurance coverage. The patients were divided into quintile according to per capita household income [27].

Logistic regression models were established to determine the socioeconomic characteristics of cancer patients associated with post-treatment household impoverishment after adjustment for variations in other variables. An enter approach was adopted in the modelling. A *p* value less than 0.05 was considered statistically significant.

6

Results

A total of 4874 cancer patient records were extracted from the participating hospitals and 2565 patients were followed up. This resulted in a final sample size of 2534 for data analyses after excluding incomplete questionnaires.

Characteristics of respondents

The respondents had an average age of 59 years (Standard Deviation = 13). About 58% were female. More than 85% came from the central (developing) and western (under-developed) regions. Less than half completed higher than senior high school education. The majority (88%) were married; 70% lived in an urban community; and nearly 50% were covered by BMIUE. About 30% engaged in farming. Lung, breast, colorectum, esophagus, liver, and stomach cancers accounted for 70% of the total cases (Table 1).

Table 1. Characteristics of study participants and post-treatment impoverishment

Characteristics	Sample size N (%)		Household consumption below China's poverty line US$1.2				Household consumption below global poverty line US$1.9			
			Number	%	χ^2	p	Number	%	χ^2	p
Gender					1.88	0.170			3.23	0.072
Male	1076	(42.46)	91	8.46			191	17.75		
Female	1458	(57.54)	102	7.00			220	15.09		
Age (years)					24.52	<0.001			40.40	<0.001
≤49	665	(26.24)	24	3.61			56	8.42		
50-69	1403	(55.37)	122	8.70			268	19.10		
≥70	466	(18.39)	47	10.09			87	18.67		
Education					51.91	<0.001			73.30	<0.001
≤ Junior high school	1392	(54.93)	149	10.70			301	21.62		
Senior high school	609	(24.03)	32	5.25			75	12.32		
≥ University	533	(21.04)	12	2.25			35	6.57		
Occupation					91.27	<0.001			167.51	<0.001
Public employee	267	(10.54)	10	3.75			25	9.36		
Commercial employee	288	(11.37)	12	4.17			25	8.68		
Peasant	745	(29.40)	118	15.84			230	30.87		
Others	1234	(48.70)	53	4.29			131	10.62		
Marital status					1.33	0.513			2.46	0.292

7

Unmarried	52	(2.05)	2	3.85			6	11.54			
Married	2224	(87.77)	172	7.73			370	16.64			
Others	258	(10.18)	19	7.36			35	13.57			
Site of cancer					21.02	0.002			36.33	<0.001	
Lung	469	(18.51)	50	10.66			98	20.90			
Breast	637	(25.14)	33	5.18			84	13.19			
Colorectum	266	(10.50)	18	6.77			42	15.79			
Esophagus	86	(3.39)	11	12.79			25	29.07			
Liver	110	(4.34)	8	7.27			19	17.27			
Stomach	200	(7.89)	24	12.00			46	23.00			
Others	766	(30.23)	49	6.40			97	12.66			
Residency					48.77	<0.001			118.34	<0.001	
Urban	1737	(68.55)	89	5.12			188	10.82			
Rural	797	(31.45)	104	13.05			223	27.98			
Region					22.96	<0.001			26.70	<0.001	
Eastern	370	(14.60)	11	2.97			28	7.57			
Central	1088	(42.94)	108	9.93			207	19.03			
Western	1076	(42.46)	74	6.88			176	16.36			
Insurance					82.59	<0.001			141.89	<0.001	
BMIUE	1210	(47.75)	37	3.06			102	8.43			
BMIUR	335	(13.22)	25	7.46			46	13.73			
NCMS	789	(31.14)	104	13.18			223	28.26			
Others	200	(7.89)	27	13.50			40	20.00			
Household income					259.63	<0.001			490.17	<0.001	
Quintile 1 (Bottom 20%)	508	(20.05)	132	25.98			241	47.44			
Quintile 2	507	(20.01)	30	5.92			80	15.78			
Quintile 3	506	(19.97)	15	2.96			47	9.29			
Quintile 4	505	(19.93)	12	2.38			27	5.35			
Quintile 5 (Top 20%)	508	(20.05)	4	0.79			16	3.15			

Note: BMIUE – Basic Medical Insurance for Urban Employees; BMIUR: Basic Medical Insurance for Urban Residents; NCMS – Rural New Cooperative Medical Scheme

8

Incidence of household impoverishment

In 2015, China reported 3.95 million new cases of cancer: 40% from rural. Almost half (48%) were reported from the eastern zone (Supplementary Table S1).

Prior to cancer treatment, 0.16% and 0.79% of the households were impoverished according to the Chinese poverty line and the global poverty line, respectively. These figures increased to 7.62% and 16.22%, respectively, after cancer treatment (Table 2).

Table 2. Household impoverishment induced by cancer treatment

Households	Percentage (number) of households below CPL US$1.2				Percentage (number) of households below WBPL US$1.9			
	Pre-treatment	Post-treatment	Pre-post difference	Estimates of impoverishment induced by cancer treatment in China	Pre-treatment	Post-treatment	Pre-post difference	Estimates of impoverishment induced by cancer treatment in China
Total	0.16 (4)	7.62 (193)	7.46 (189)	7.46 (294908)	0.79 (20)	16.22 (411)	15.43 (391)	15.43 (610101)
Rural	0.00 (0)	13.05 (104)	13.05 (104)	13.05 (209856)	1.76 (14)	27.98 (223)	26.22 (209)	26.22 (421729)
Urban	0.23 (4)	5.12 (89)	4.89 (85)	4.89 (117180)	0.35 (6)	10.82 (188)	10.48 (182)	10.48 (250903)
Eastern	0.00 (0)	2.97 (11)	2.97 (11)	2.97 (54043)	0.00 (0)	7.57 (28)	7.57 (28)	7.57 (137564)
Central	0.28 (3)	9.93 (108)	9.65 (105)	9.65 (104944)	1.10 (12)	19.03 (207)	17.92 (195)	17.92 (194895)
Western	0.09 (1)	6.88 (74)	6.78 (73)	6.78(62002)	0.74 (8)	16.36 (176)	15.61 (168)	15.61 (142690)

9

There was an increase of 7.46% households living in poverty after cancer treatment according to the Chinese poverty line. This amounted to 294,908 households. These figures increased to 15.43% and 610,101 households using the global poverty line. The chance of falling into poverty after cancer treatment in rural residents was almost three times of those living in an urban community. Those living in the less developed western and central regions were also two or three times more likely to experience household impoverishment resulting from cancer treatment compared with their more developed eastern counterparts. Rural households and those living in the central region had the biggest increase in impoverishment resulting from cancer treatment (Table 2).

Older patients were more likely to experience post-treatment household impoverishment than their younger counterparts ($p<0.001$). Peasants and those who received lower levels of education were more likely to be impoverished than others ($p<0.001$). Higher incidence of post-treatment household impoverishment was found in the respondents with lung, esophagus, and stomach cancers ($p<0.001$). There existed significant regional and wealth-related disparities in incidence of post-treatment household impoverishment. The patients who lived in the less developed central and western regions, had a rural residency, and enrolled with the less generous NCMS had a higher incidence of post-treatment household impoverishment than others ($p<0.001$). The lowest quintile of income group had 25.98% incidence of post-treatment household impoverishment, compared with less than 6% incidence of the other income groups ($p<0.001$). No significant differences were found in incidence of post-treatment household impoverishment across gender and marital status (Table 1).

10

Socioeconomic inequalities in household impoverishment

The households with the lowest quintile of income were hardest hit by cancer treatment, with 25.39% households falling into poverty under the Chinese line as a result of cancer treatment compared with 44.49% under the global poverty line. These figures were at least four times higher than those of the households with higher income. Inequalities in financial protection functions of the social health insurance programs were evident. The rural patients enrolled with NCMS had similar levels of incidence of household impoverishment as compared with those without a coverage of any of the social health insurance programs, much higher than those covered by the two urban insurance programs BMIUE and BMIUR (Table 3).

Table 3. Inequality in household impoverishment induced by cancer treatment

Characteristics of cancer patients	Percentage (number) of households below CPL US$1.2			Percentage (number) of households below WBPL US$1.9		
	Pre-treatment	Post-treatment	Pre-post difference	Pre-treatment	Post-treatment	Pre-post difference
Health insurance						
BMIUE	0.17 (2)	3.06 (37)	2.89 (35)	0.25 (3)	8.43 (102)	8.18 (99)
BMIUR	0.60 (2)	7.46 (25)	6.87 (23)	0.60 (2)	13.73 (46)	13.13 (44)
NCMS	0.00 (0)	13.18 (104)	13.18 (104)	1.77 (14)	28.26 (223)	26.49 (209)
Others	0.00(0)	13.50 (27)	13.50(27)	0.50(1)	20.00(40)	19.50 (39)
Household income						
Quintile 1 (Bottom 20%)	0.59 (3)	25.98 (132)	25.39 (129)	2.95 (15)	47.44 (241)	44.49 (226)
Quintile 2	0.20 (1)	5.92 (30)	5.72 (29)	0.99 (5)	15.78 (80)	14.79 (75)
Quintile 3	0.00 (0)	2.96 (15)	2.96 (15)	0.00 (0)	9.29 (47)	9.29 (47)
Quintile 4	0.00 (0)	2.38 (12)	2.38 (12)	0.00 (0)	5.35 (27)	5.35 (27)
Quintile 5 (Top 20%)	0.00 (0)	0.79 (4)	0.79 (4)	0.00 (0)	3.15 (16)	3.15 (16)

The logistic regression model showed that the incidence of post-treatment household impoverishment was associated with age, site of cancer, region, social health insurance, and household income after adjustment for variations in other variables. The incidence of post-treatment household impoverishment increased with age. The patients with breast cancer had lower odds (AOR=0.538, *p*=0.014) of experiencing post-treatment household impoverishment than those with lung cancer. The odds of the households in the central region (AOR=2.619, *p*=0.006) experiencing post-treatment household impoverishment more than doubled that in the most developed eastern region.

11

Significant lower odds ($p<0.001$) of post-treatment household impoverishment were found in the households with higher income compared with those in the lowest quintile of income group. The patients without a coverage of any of the three social health insurance had higher odds (AOR=1.880, p=0.040) of experiencing post-treatment household impoverishment than those enrolled with BMIUE (Table 4).

Table 4. Logistic regression analysis on predictors of the incidence of post-treatment impoverishment in cancer patients

Characteristics of cancer patients	Crude Odds Ratio (95%CI)	p	Adjusted Odds Ratio (95%CI)	p
Age (years)				
≤49	1 (reference)		1 (reference)	
50-69	2.544 (1.625-3.981)	<0.001	2.666 (1.659-4.285)	<0.001
≥70	2.996 (1.805-4.974)	<0.001	4.187 (2.400-7.305)	<0.001
Educational attainment				
≤ Junior high school	1 (reference)		1 (reference)	
Senior high school	0.463 (0.312-0.686)	<0.001	0.987 (0.637-1.530)	0.955
≥ University	0.192 (0.106-0.349)	<0.001	1.166 (0.572-2.376)	0.673
Occupation				
Public employee	1 (reference)		1 (reference)	
Commercial employee	1.117 (0.475-2.631)	0.799	0.731 (0.287-1.864)	0.511
Peasant	4.837 (2.496-9.373)	<0.001	0.818 (0.341-1.964)	0.653
Others	1.153 (0.579-2.297)	0.685	0.597 (0.271-1.316)	0.201
Site of cancer				
Lung	1 (reference)	0.002	1 (reference)	
Breast	0.458 (0.290-0.723)	0.001	0.538 (0.328-0.882)	0.014
Colorectum	0.608 (0.347-1.066)	0.082	0.624 (0.342-1.140)	0.125
Esophagus	1.229 (0.612-2.469)	0.562	0.703 (0.328-1.504)	0.363
Liver	0.657 (0.302-1.430)	0.290	0.830 (0.362-1.903)	0.660
Stomach	1.143 (0.681-1.917)	0.613	0.818 (0.463-1.444)	0.488
Others	0.573 (0.379-0.865)	0.008	0.513 (0.324-0.814)	0.005
Residency				
Urban	1 (reference)		1 (reference)	
Rural	2.779 (2.066-3.738)	<0.001	0.993 (0.692-1.425)	0.970
Region				

12

Eastern	1 (reference)		1 (reference)	
Central	3.597 (1.912-6.767)	<0.001	2.619 (1.317-5.206)	0.006
Western	2.410 (1.265-4.593)	0.007	1.535 (0.766-3.076)	0.227
Health insurance				
BMIUE	1 (reference)		1 (reference)	
BMIUR	2.557 (1.516-4.312)	<0.001	1.225 (0.683-2.195)	0.496
NCMS	4.813 (3.269-7.087)	<0.001	1.355 (0.827-2.219)	0.228
Others	4.948 (2.938-8.332)	<0.001	1.880 (1.030-3.431)	0.040
Household income				
Quintile 1 (Bottom 20%)	1 (reference)		1 (reference)	
Quintile 2	0.179 (0.118-0.272)	<0.001	0.187 (0.121-0.288)	<0.001
Quintile 3	0.087 (0.050-0.151)	<0.001	0.094 (0.052-0.171)	<0.001
Quintile 4	0.069 (0.038-0.127)	<0.001	0.072 (0.037-0.142)	<0.001
Quintile 5 (Top 20%)	0.023 (0.008-0.062)	<0.001	0.024 (0.008-0.070)	<0.001

The median consumption gap accumulated by the impoverished households post cancer treatment reached US$128 per capita per year underneath the CPL and US$212 per capita per year underneath the WBPL, respectively. These amounted to a total of US$ 43 million (under CPL) and US$ 152 million (under WBPL) needed to avoid household impoverishment induced by cancer treatment. The impoverished households with the lowest quintile of income also accumulated twice or tripled consumption gaps underneath the poverty line in comparison with their wealthiest counterpart (Supplementary Table S2).

Discussion

This study presents new evidence on household impoverishment induced by cancer treatment in China. About 7.46% of households became impoverished according to the CPL after paying for cancer treatment out of pocket. This figure would increase to 15.43% using the WBPL. Such an incidence appears to be low compared with findings of studies conducted in some other developing countries [11]. The interpretation of the comparative results needs to be cautious. In this study and others undertaken in China [28], indirect costs associated with medical services such as transportation, foods, and out of hospital accommodations were not included in the estimation of costs for cancer treatment. This may have deflated the real financial burden of cancer treatment in China.

The social health insurance programs have limited effects on preventing household impoverishment induced by cancer treatment. Although patients without a coverage of

13

any of the three social health insurance programs are more likely to experience post-treatment household impoverishment than those enrolled with BMIUE, significant increases in household impoverishment after cancer treatment occurred in enrollees of all the three insurance programs. Patients covered by NCMS appear to have the same chance of falling into poverty as those without coverage of any of the social health insurance programs. Previous studies found that funding available for NCMS enrollees is only about half of that for BMIUE enrollees [29]. Empirical evidence shows that public financing is effective in protecting the most vulnerable populations from medical-induced poverty [30-32]. However, this requires well targeted investments (the so-called precision poverty alleviation) [33]. This study estimates that at least 43 million US dollars will be needed annually to alleviate the impoverishment induced by cancer treatment according to the CPL, or 152 million US dollars according to the WBPL.

Socioeconomic inequality in household impoverishment resulting from cancer treatment in China deserves increasing policy attention. This study found that inequalities exist from a range of perspectives: (1) Households with the lowest quintile of income stand at least four times higher chance of falling into poverty after cancer treatment than the richer ones: more than one quarter of them became impoverished under the Chinese poverty line or almost 45% under the global poverty line. These results are consistent with findings of other studies [34-36]. (2) Rural households have tripled incidence of impoverishment induced by cancer treatment compared with the urban ones. The urban-rural inequality is likely to be a result of income disparities [37] and disparities in primary care services [38, 39]. The urban-rural difference in incidence of post-treatment household impoverishment disappeared after adjustment for variations in other variables. (3) Like findings of previous studies[11], older people were found in this study to suffer more from household impoverishment as a result of cancer treatment. (4) Significant regional disparities exist. Although it is certain that the most developed eastern region is better off, the central developing region suffers more than the poorest western region. In 2015, disposable income of the central region averaged at US$2961 per capita, compared with US$4531 in the eastern and US$2708 in the western region [40]. However, the national government of China has provided significantly more financial subsidies to the western region than to the central region. Previous studies also show that patients from the central region are more likely to seek more expensive medical services compared with their western counterparts due to higher financial capability, convenience of transportation and better accessibility to high medical technologies [41]. Indeed, low household income may suppress the demands of patients despite wide coverage of health insurance according to the findings of this study.

Findings of this study have some policy implications. The current health insurance programs in China are highly fragmented. A better coordinated effort is needed to address the inequality in household impoverishment induced by cancer treatment. This

14

can start from a national central cancer registry system and share of insurance claim data given that the national government of China has been increasing its investments in social health insurance, health services delivery, and medical assistance (to help poor households to enroll with social health insurance and pay for OOP expenses) programs. Government investments need to be channeled to those most in need [42]. The role of primary care in managing cancer patients should also be strengthened.

This study has several limitations. Data in this study were collected through questionnaire survey, which are subject to recall bias. Household impoverishment was determined by daily consumption in this study, which is a widely accepted approach. However, we did not examine the source of income for household consumptions. If some households borrowed money to pay for daily consumption, this could lead to potential underestimation of household impoverishment.

Conclusion

The financial burden of cancer treatment imposes a significant risk of household impoverishment in China despite an almost universal coverage of social health insurance. The risk falls disproportionally onto the households living with low income. Significant socioeconomic inequalities exist in household impoverishment resulting from cancer treatment. Unbalanced regional development and fragmentation of health insurance programs may have jeopardized the efforts in alleviating poverty induced by medical services.

Abbreviation list

CPL: Chinese poverty line;

WBPL: World Bank poverty line;

OOP: out-of-pocket payment;

BMIUE: basic medical insurance for urban employees;

BMIUR: basic medical insurance for urban resident;

NCMS: rural new cooperative medical scheme

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Footnotes

Contributors

All of the authors made intellectual contributions to the conceptualisation of this study, gave final approval of the version to be published, and agreed to be accountable for all

17

aspects of the work. Wen-Qi Fu, Guo-Xiang Liu, Ju-Fang Shi and Chaojie Liu contributed to the development of the analysis framework, interpretation of the study findings, and revisions of the manuscript. Wen-Qi Fu, Yu-Peng Du and Hong Wang performed data analyses. Wen-Qi Fu wrote the draft. Other authors participated in field investigation, data collection and data management. Wen-Qi Fu, Ju-Fang Shi contributed equally to this paper.

Competing interests: None declared.

Ethics approval: The study protocol was approved by the Institutional Review Board of the Cancer Hospital of Chinese Academy of Medical Sciences (Approval No. 15-071/998).

Provenance and peer review: Not commissioned; externally peer reviewed.

Data sharing statement: No additional data are available.

Patient and public involvement statement: Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

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Table 1. Characteristics of study participants and post-treatment impoverishment

Characteristics	Sample size N (%)		Household consumption below China's poverty line US$1.2				Household consumption below global poverty line US$1.9			
			Number	%	χ^2	p	Number	%	χ^2	p
Gender					1.88	0.170			3.23	0.072
Male	1076	(42.46)	91	8.46			191	17.75		
Female	1458	(57.54)	102	7.00			220	15.09		
Age (years)					24.52	<0.001			40.40	<0.001
≤49	665	(26.24)	24	3.61			56	8.42		
50-69	1403	(55.37)	122	8.70			268	19.10		
≥70	466	(18.39)	47	10.09			87	18.67		
Education					51.91	<0.001			73.30	<0.001
≤ Junior high school	1392	(54.93)	149	10.70			301	21.62		
Senior high school	609	(24.03)	32	5.25			75	12.32		
≥ University	533	(21.04)	12	2.25			35	6.57		
Occupation					91.27	<0.001			167.51	<0.001
Public employee	267	(10.54)	10	3.75			25	9.36		
Commercial employee	288	(11.37)	12	4.17			25	8.68		
Peasant	745	(29.40)	118	15.84			230	30.87		
Others	1234	(48.70)	53	4.29			131	10.62		
Marital status					1.33	0.513			2.46	0.292
Unmarried	52	(2.05)	2	3.85			6	11.54		
Married	2224	(87.77)	172	7.73			370	16.64		
Others	258	(10.18)	19	7.36			35	13.57		
Site of cancer					21.02	0.002			36.33	<0.001
Lung	469	(18.51)	50	10.66			98	20.90		
Breast	637	(25.14)	33	5.18			84	13.19		
Colorectum	266	(10.50)	18	6.77			42	15.79		
Esophagus	86	(3.39)	11	12.79			25	29.07		
Liver	110	(4.34)	8	7.27			19	17.27		
Stomach	200	(7.89)	24	12.00			46	23.00		
Others	766	(30.23)	49	6.40			97	12.66		
Residency					48.77	<0.001			118.34	<0.001

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	N	(%)	n	%	χ²	p	n	%	χ²	p
Urban	1737	(68.55)	89	5.12			188	10.82		
Rural	797	(31.45)	104	13.05			223	27.98		
Region					22.96	<0.001			26.70	<0.001
Eastern	370	(14.60)	11	2.97			28	7.57		
Central	1088	(42.94)	108	9.93			207	19.03		
Western	1076	(42.46)	74	6.88			176	16.36		
Insurance					82.59	<0.001			141.89	<0.001
BMIUE	1210	(47.75)	37	3.06			102	8.43		
BMIUR	335	(13.22)	25	7.46			46	13.73		
NCMS	789	(31.14)	104	13.18			223	28.26		
Others	200	(7.89)	27	13.50			40	20.00		
Household income					259.63	<0.001			490.17	<0.001
Quintile 1 (Bottom 20%)	508	(20.05)	132	25.98			241	47.44		
Quintile 2	507	(20.01)	30	5.92			80	15.78		
Quintile 3	506	(19.97)	15	2.96			47	9.29		
Quintile 4	505	(19.93)	12	2.38			27	5.35		
Quintile 5 (Top 20%)	508	(20.05)	4	0.79			16	3.15		

Note: BMIUE – Basic Medical Insurance for Urban Employees; BMIUR: Basic Medical Insurance for Urban Residents; NCMS – Rural New Cooperative Medical Scheme

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Table 2. Household impoverishment induced by cancer treatment

Households	Percentage (number) of households below CPL US$1.2				Percentage (number) of households below WBPL US$1.9			
	Pre-treatment	Post-treatment	Pre-post difference	Estimates of impoverishment induced by cancer treatment in China	Pre-treatment	Post-treatment	Pre-post difference	Estimates of impoverishment induced by cancer treatment in China
Total	0.16 (4)	7.62 (193)	7.46 (189)	7.46 (294908)	0.79 (20)	16.22 (411)	15.43 (391)	15.43 (610101)
Rural	0.00 (0)	13.05 (104)	13.05 (104)	13.05 (209856)	1.76 (14)	27.98 (223)	26.22 (209)	26.22 (421729)
Urban	0.23 (4)	5.12 (89)	4.89 (85)	4.89 (117180)	0.35 (6)	10.82 (188)	10.48 (182)	10.48 (250903)
Eastern	0.00 (0)	2.97 (11)	2.97 (11)	2.97 (54043)	0.00 (0)	7.57 (28)	7.57 (28)	7.57 (137564)
Central	0.28 (3)	9.93 (108)	9.65 (105)	9.65 (104944)	1.10 (12)	19.03 (207)	17.92 (195)	17.92 (194895)
Western	0.09 (1)	6.88 (74)	6.78 (73)	6.78(62002)	0.74 (8)	16.36 (176)	15.61 (168)	15.61 (142690)

The Pen's Parade graph showed widening gaps between pre-treatment and post-treatment household consumptions along the x-axis. This indicates that the wealthier households spent more money in cancer treatment than their poorer counterparts despite a less likelihood of falling into poverty (Figure 1).
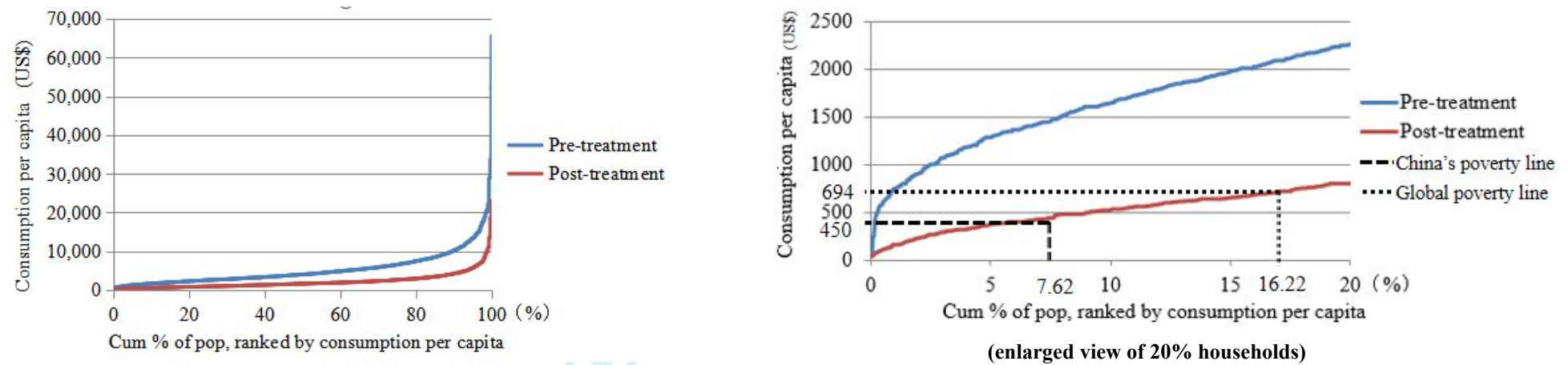
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Figure 1. Pen's Parade of impoverished households before and after cancer treatment

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Table 3. Inequality in household impoverishment induced by cancer treatment

Characteristics of cancer patients	Percentage (number) of households below CPL US$1.2			Percentage (number) of households below WBPL US$1.9		
	Pre-treatment	Post-treatment	Pre-post difference	Pre-treatment	Post-treatment	Pre-post difference
Health insurance						
BMIUE	0.17 (2)	3.06 (37)	2.89 (35)	0.25 (3)	8.43 (102)	8.18 (99)
BMIUR	0.60 (2)	7.46 (25)	6.87 (23)	0.60 (2)	13.73 (46)	13.13 (44)
NCMS	0.00 (0)	13.18 (104)	13.18 (104)	1.77 (14)	28.26 (223)	26.49 (209)
Others	0.00(0)	13.50 (27)	13.50(27)	0.50(1)	20.00(40)	19.50 (39)
Household income						
Quintile 1 (Bottom 20%)	0.59 (3)	25.98 (132)	25.39 (129)	2.95 (15)	47.44 (241)	44.49 (226)
Quintile 2	0.20 (1)	5.92 (30)	5.72 (29)	0.99 (5)	15.78 (80)	14.79 (75)
Quintile 3	0.00 (0)	2.96 (15)	2.96 (15)	0.00 (0)	9.29 (47)	9.29 (47)
Quintile 4	0.00 (0)	2.38 (12)	2.38 (12)	0.00 (0)	5.35 (27)	5.35 (27)
Quintile 5 (Top 20%)	0.00 (0)	0.79 (4)	0.79 (4)	0.00 (0)	3.15 (16)	3.15 (16)

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Table 4. Logistic regression analysis on predictors of the incidence of post-treatment impoverishment in cancer patients

Characteristics of cancer patients	Crude Odds Ratio (95%CI)	p	Adjusted Odds Ratio (95%CI)	p
Age (years)				
≤49	1 (reference)		1 (reference)	
50-69	2.544 (1.625-3.981)	<0.001	2.666 (1.659-4.285)	<0.001
≥70	2.996 (1.805-4.974)	<0.001	4.187 (2.400-7.305)	<0.001
Educational attainment				
≤ Junior high school	1 (reference)		1 (reference)	
Senior high school	0.463 (0.312-0.686)	<0.001	0.987 (0.637-1.530)	0.955
≥ University	0.192 (0.106-0.349)	<0.001	1.166 (0.572-2.376)	0.673
Occupation				
Public employee	1 (reference)		1 (reference)	
Commercial employee	1.117 (0.475-2.631)	0.799	0.731 (0.287-1.864)	0.511
Peasant	4.837 (2.496-9.373)	<0.001	0.818 (0.341-1.964)	0.653
Others	1.153 (0.579-2.297)	0.685	0.597 (0.271-1.316)	0.201
Site of cancer				
Lung	1 (reference)	0.002	1 (reference)	
Breast	0.458 (0.290-0.723)	0.001	0.538 (0.328-0.882)	0.014
Colorectum	0.608 (0.347-1.066)	0.082	0.624 (0.342-1.140)	0.125
Esophagus	1.229 (0.612-2.469)	0.562	0.703 (0.328-1.504)	0.363
Liver	0.657 (0.302-1.430)	0.290	0.830 (0.362-1.903)	0.660
Stomach	1.143 (0.681-1.917)	0.613	0.818 (0.463-1.444)	0.488
Others	0.573 (0.379-0.865)	0.008	0.513 (0.324-0.814)	0.005
Residency				
Urban	1 (reference)		1 (reference)	
Rural	2.779 (2.066-3.738)	<0.001	0.993 (0.692-1.425)	0.970
Region				
Eastern	1 (reference)		1 (reference)	
Central	3.597 (1.912-6.767)	<0.001	2.619 (1.317-5.206)	0.006
Western	2.410 (1.265-4.593)	0.007	1.535 (0.766-3.076)	0.227
Health insurance				

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BMIUE	1 (reference)		1 (reference)	
BMIUR	2.557 (1.516-4.312)	<0.001	1.225 (0.683-2.195)	0.496
NCMS	4.813 (3.269-7.087)	<0.001	1.355 (0.827-2.219)	0.228
Others	4.948 (2.938-8.332)	<0.001	1.880 (1.030-3.431)	0.040
Household income				
Quintile 1 (Bottom 20%)	1 (reference)		1 (reference)	
Quintile 2	0.179 (0.118-0.272)	<0.001	0.187 (0.121-0.288)	<0.001
Quintile 3	0.087 (0.050-0.151)	<0.001	0.094 (0.052-0.171)	<0.001
Quintile 4	0.069 (0.038-0.127)	<0.001	0.072 (0.037-0.142)	<0.001
Quintile 5 (Top 20%)	0.023 (0.008-0.062)	<0.001	0.024 (0.008-0.070)	<0.001

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Supplementary File

Table S1. New cases of cancer recorded in China, 2015

Location	No. population (100,000) [28]	Incidence (per 100,000 population)⁻¹[29]	Number (percentage) of cases
Total	13,746	288	3,953,957 (100%)
Residency			
Rural	6,035	267	1,608,221 (40%)
Urban	7,712	311	2,394,606 (60%)
Zone			
Eastern	5,690	319	1,817,816 (48%)
Central	4,305	253	1,087,415 (28%)
Western	3,751	244	913,896 (24%)

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Table S2. Accumulated consumption gap post cancer treatment in impoverished households in China

Characteristics of cancer patients	Total (median) annual US$ gap per capita, US$		Estimates of impoverishment induced by cancer treatment, US$	
	Households below CPL US$1.2	Households below WBPL US$1.9	Households below CPL US$1.2	Households below WBPL US$1.9
Total	27488 (128)	91081 (212)	43456740	151675531
Residency				
Rural	15179 (127)	48080 (212)	30629784	106638491
Urban	12308 (128)	43001 (212)	17468019	61150812
Region				
Eastern	1266 (71)	6108 (220)	6221542	30010513
Central	15616 (134)	48746 (212)	15777767	52298712
Western	10605 (122)	36226 (182)	9171086	32929233
Health insurance				
BMIUE	5699 (128)	21245 (172)		
BMIUR	2589 (91)	10201 (255)		
NCMS	15179 (127)	48080 (212)		
Others	4019 (148)	11555 (292)		
Household income				
Quintile 1 (Bottom 20%)	19020 (132)	58289 (256)		
Quintile 2	4451 (112)	14997 (185)		
Quintile 3	1698 (82)	8713 (148)		
Quintile 4	2110 (150)	6307 (158)		
Quintile 5 (Top 20%)	209 (44)	2774 (153)		

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	He, Jie; Chinese Academy of Medical Sciences and Peking Union Medical College, Office of Cancer Screening, National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital
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Household impoverishment induced by cancer treatment: a multicenter cross-sectional study in China

Wenqi Fu,[a,*] Jufang Shi,[b,*] Xin Zhang,[a] Chengcheng Liu,[b] Chengyao Sun,[a] Yupeng Du,[a] Hong Wang,[a] Chaojie Liu,[c] Li Lan,[d] Min Zhao,[e] Li Yang,[f] Burenbatu Bao,[g] Sumei Cao,[h] Yongzhen Zhang,[i] Debin Wang,[j] Ni Li,[b] Wanqing Chen,[b] Min Dai,[b] Guoxiang Liu,[a] Jie He[b]

*Contributed equally to this work.

Correspondence to: Guoxiang Liu, lgx6301@163.com; Min Dai, daimin2002@hotmail.com; Wanqing Chen, chenwq@cicams.ac.cn

[a] School of Health Management / Public Health, Harbin Medical University, Harbin 150081, China

[b] Office of Cancer Screening, National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing 100021, China

[c] School of Psychology and Public Health, La Trobe University, Melbourne VIC 3086, Australia

[d] Institute for Prevention and Control of Chronic Non-communicable Diseases, Harbin Center for Disease Control and Prevention, Harbin, 150056, China

[e] Department of Medical Administration, Yunnan Provincial Cancer Hospital, Kunming 650118, China

[f] School of Public Health, Guangxi Medical University 530021, China

[g] Department of Hematology and oncology, Affiliated Hospital of Inner Mongolia University for Nationalities, Tongliao, 028050, China

[h] Department of Cancer Prevention, Sun Yat-sen University Cancer Center, Guangzhou, 510060, China

[i] Department of Epidemiology, Shanxi Provincial Cancer Hospital, Taiyuan, 030013, China

[j] Health Management College, Anhui Medical University, Hefei 230032, China

1

Abstract

Objectives: to determine the incidence and intensity of household impoverishment induced by cancer treatment in China.

Design: Average income and daily consumption per capita of the households and out-of-pocket payments for cancer care were estimated. Household impoverishment was determined by comparing per capita daily consumption against the Chinese poverty line (CPL, US$1.2) and the World Bank poverty line (WBPL, US$1.9) for 2015. Both pre-treatment and post-treatment consumptions were calculated assuming that the households would divert daily consumption money to pay for cancer treatment.

Participants: Cancer patients diagnosed initially from 01 January 2015 to 31 December 2016 who had received cancer treatment subsequently. Those with multiple cancer diagnoses were excluded.

Data sources: A household questionnaire survey was conducted on 2534 cancer patients selected from nine hospitals in seven provinces through two-stage cluster/convenience sampling.

Findings: 5.89% (CPL) to 12.94% (WBPL) households were impoverished after paying for cancer treatment. The adjusted odds ratio (AOR) of post-treatment impoverishment was higher for older patients (AOR=2.666-4.187 for $\geqslant$50 years vs <50 years, p<0.001), those resided in central region (AOR=2.619 vs eastern, p<0.01), and those with lower income (AOR=0.024-0.187 in higher income households vs the lowest 20%, p<0.001). The patients without coverage from social health insurance had higher odds (AOR=1.880, p=0.040) of experiencing post-treatment household impoverishment than those enrolled with the insurance for urban employees. Cancer treatment is associated with an increase of 5.79% (CPL) and 12.45% (WBPL) in incidence of household impoverishment. The median annual consumption gap per capita underneath the poverty line accumulated by the impoverished households reached US$128 (CPL) or US$212 (WBPL). US$31,170,395 (CPL) or US$115,238,459 (WBPL) were needed to avoid household impoverishment induced by cancer treatment in China.

Conclusions: The financial burden of cancer treatment imposes a significant risk of household impoverishment despite wide coverage of social health insurance in China.

Keywords: Household impoverishment; Cancer; Out-of-pocket payment; China

Strengths and limitations of this study

- This is one of the few studies involving a large sample of cancer patients in China.

- Household impoverishment induced by cancer treatment was estimated, including its socioeconomic inequalities.

- National funds required for alleviating household impoverishment induced by

2

cancer treatment were estimated based on new cases of cancer diagnosis.

- Patients with multiple cancer diagnoses were excluded from the study.

- Data were collected through a questionnaire survey, which are subject to recall bias.

Introduction

Cancer causes enormous physical and mental harm on patients and their families [1]. In 2012, 14.1 million new cases of cancer were reported in the world and 8.2 million cancer patients died. These figures surged to 18.1 million and 9.6 million, respectively, in 2018 [2, 3]. A further 75% increase in new cases of cancer over the next two decades is anticipated [4]. China bears the highest burden of cancer, ranking on top of the world not only in absolute numbers and deaths but also in proportion to the population size [4]. It was estimated that 4.3 million new cancer cases were diagnosed and 2.8 million died from cancer in China in 2015 [5]. Cancer has become the leading cause of death in China. The rising trend of cancer shows no sign of containment [6].

The costs of cancer treatment put a great financial stress on cancer patients and their families. According to the Medical Panel Expenditure Survey, the households with a cancer survivor in the US paid on average US\$2304 out of pocket (OOP) every year over the period from 2008 to 2016 [7]. The annual OOP spending on metastatic breast cancer treatment in the US during 2004 to 2011 reached US\$6642 [8]. A multicenter cross-sectional survey in China over the period from 2012 to 2014 showed that the OOP spending of cancer treatment in the first year averaged at US\$4947, which equaled to 57.5% of the average annual household income. About 77.6% of the households with a cancer patient experienced unmanageable financial difficulties [9].

The high cost of cancer treatment has imposed disproportional burdens on the households living with low income. They are more prone to falling into impoverishment as a result of OOP payments for cancer treatment. This has prompted the World Health Organization to call for increasing policy attention addressing the inequality issue through a systems approach [10-12]. A study in Heilongjiang, a province ranked in the middle range of economic development in China, showed that as many as 86% of households with a cancer patient could become impoverished as a result of cancer treatment [13].

Health insurance has been widely accepted as an effective strategy to prevent household impoverishment induced by cancer treatment [14]. Although extensive studies have been conducted on the relationship between cancer and poverty [15-18], there is paucity in the literature documenting the situation in low- and middle-income countries [11]. Most low- and middle-income countries cannot afford the same level of insurance entitlements as their high-income counterparts. Internationally, little is known about inequality of household impoverishment resulting from cancer treatment and the role of health insurance in alleviating cancer-induced impoverishment [19].

This study aimed to determine the incidence and intensity of household

3

impoverishment induced by cancer treatment in China. By 2015, more than 95% of Chinese citizens had been covered by social health insurance [20]. However, there have been significant disparities in insurance entitlements across regions, between urban and rural, and across different insurance programs [21]. There are three social health insurance programs subsidized by the government: Basic Medical Insurance for Urban Employees (BMIUE), Basic Medical Insurance for Urban Residents (BMIUR), and the New Cooperative Medical Scheme (NCMS). The BMIUE was initiated in 1998 with premium contributions from both employers and employees, covering urban employees and retirees in the formal sector, including those who previously enjoyed free medical care offered by public agencies and state-owned enterprises. Funding resources for the NCMS (initiated in 2003) and BMIUR (initiated in 2007) come from both individual voluntary contributions and local governmental subsides. The former covers rural residents, while the latter covers the urban residents who are not eligible for the BMIUE, such as those self-employed, unemployed, children, and students. All these three programs are managed at the municipal or county level with varied funding pools and benefit policies. The BMIUE enrollees enjoy a relatively higher level of entitlements compared with the other two. Recently, the NCMS and BMIUR started to merge in some regions [20, 22, 23]. There is a shortage of research into the role of these insurance programs in preventing poverty induced by medical care services. The State Council of China made it clear in 2016 that disease-associated poverty would be given priority in the governmental poverty alleviating campaign [24].

Methods

Study design and sites

A multicenter cross-sectional survey was conducted from January 2018 to June 2019 as part of the Cancer Screening Program in Urban China [25]. Geographic regions/provinces were grouped into eastern, central and western in line with the classification of economic development zones by the National Bureau of Statistics. Nine tertiary hospitals were purposively selected from these zones considering cancer patient volumes and completeness of medical records, including Guangdong Cancer Hospital (eastern), Anhui Cancer Hospital, Heilongjiang Cancer Hospital, Shanxi Cancer Hospital (central), Guangxi Cancer Hospital, Yunnan Cancer Hospital, the Regional Cancer Hospital and two city hospitals in Inner Mongolia (western).

Study participants

Cancer patients diagnosed initially over the period from 01 January 2015 to 31 December 2016 were eligible for this study. They had to receive cancer treatment subsequently. Eligible participants were those who had one primary cancer (including metastatic cancer). Those with two or more primary cancer diagnoses were excluded. The eligibility of study participants was assessed through the hospital records. Lung, breast, colorectum, esophageal, liver, and stomach cancers accounted for 70% of the total sample. About 27.50% were diagnosed with a cancer in stage III or stage IV.

Previous study showed that about 20% households with cancer patients might live in poverty. A sample size of 1600 would allow an estimation of the impoverishment rate

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with 2% precision as α being set at 0.05 [26]. Given the rapid development of social health insurance in recent years, cancer-induced impoverishment may have dropped significantly. We increased the sample size to 2500, with a minimal of 360 patients being contacted in each participating province. In each province, 720 medical records of cancer patients were randomly extracted for the follow-up survey.

Outcome Indicators

Impoverished households were identified by assessing household consumption against the poverty line [27]. This included regular and repeated expenses to satisfy the essential needs of household members, which only counted the expenses paid out of pocket, not including those subsidized by the government and insurance. A daily household consumption below US$1.2 per capita per day (US$438 per year) in the 2015 value was deemed impoverishment according to the State Council of China. Globally, poverty line was set at US$1.90 per capita per day (US$694 per year) in the 2015 value by the World Bank [28].

The primary outcome indicators included (1) incidence of household impoverishment as a percentage of households living under the poverty line; and (2) intensity of household impoverishment reflected by the distance of household consumption per capita from the poverty line, which was calculated as the monetary value difference between the poverty line and per capita household consumption after paying for cancer treatment [27].

The marginal contribution of cancer treatment to household impoverishment was calculated as the difference in incidence of household impoverishment pre- and post-cancer treatment. The expenditure associated with cancer diagnosis and treatment was counted as pre-treatment consumption, which was subsequently deprived from post-treatment consumption. The national scale of impoverishment resulting from cancer treatment was estimated based on the number of new cancer cases reported in 2015 across the three regions in China. A weighting system was applied based on the number of new cancer cases in the estimation of national incidence of household impoverishment: 0.48 for eastern, 0.28 for central, and 0.24 for western.

Data Collection

Eligible study participants were identified from the hospital records and then approached for a questionnaire survey. The questionnaire was administered through face-to-face interviews over the period from March to December 2018. The survey was coordinated by the National Cancer Center. The interviewers were trained prior to deployment and required to check completeness of the questionnaire before concluding each interview.

In each household, either the patient or her/his primary family caregiver was invited to respond to the questionnaire. Participation was voluntary. Written informed consent was obtained prior to each interview. Of the returned questionnaires, 53% were

5

completed by the patients, compared with 47% by their family caregivers (Supplementary Table S1). The respondents were asked to estimate OOP payments for cancer treatment over a one-year period (two months before and ten months after diagnosis of the cancer). These included OOP payments for hospital diagnosis and treatment and medicines (both prescribed and non-prescribed) purchased from pharmacy retail outlets.

The household income and consumption data covered both 2015 and 2016. Average income and consumption across the two years were calculated to match the cancer treatment cost data due to difficulties to articulate a clear cut-off point for the income and consumption data.

The questionnaire items measuring household income and consumption (Supplementary Table S2) were derived from the National Health Services Survey and the Statistical Bulletin on National Economic and Social Development in China. Income included salary, return on capital investments, dividends and interests, governmental subsidies and gifts. Household consumptions included foods, clothing, daily necessities, transportation, communication, housing (mortgage/rents and utilities), education, medical care, insurance, and cultural and entertainment activities. Capital investments and repairments and other profit generating investment activities were excluded.

In this study, we only estimated direct OOP payments for cancer treatment (Supplementary Table S1). Indirect costs associated with transportation and travel, meals, and informal caregivers were excluded. All of the three social health insurance programs had very detailed descriptions of covered items. The insured patients needed to pay for all of the uncovered items (including some drugs for cancer therapy). On top of that, there were deductible (insurance compensations would start only when medical expenditure exceeded a defined minimal level), copayments (share of fee between insurance and the insured), and ceiling requirements (insurance would stop compensations once the expenses reached a defined maximal level).

Data were double-entered into EpiData 3.1 to ensure accuracy.

Data Analysis

Data about cancer treatment expenditure, household income and consumption were converted to the 2015 value of US dollars (1 USD = 6.2284 Chinese Yuan) for the purpose of assessing impoverishment against the 2015 poverty line set up by the State Council of China and the World Bank.

Pen's Parade graphs were produced to visualize the effect of OOP payments for cancer treatment on household impoverishment. Per-capita household consumptions were plotted along the y-axis against the cumulative percentage of households ranked by per capita household consumptions along the x-axis for pre-treatment and post-treatment, respectively. The graphs give a clear indication on the proportion of households living below the poverty line. The area covered by the parade of those

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below the poverty line indicates the gap in household consumption that needs to fill up to alleviate poverty [27].

Inequality in household impoverishment induced by cancer treatment was assessed by comparing the pre-post treatment differences in incidence of household impoverishment in patients with different household incomes and insurance coverage. The patients were divided into quintile according to per capita household income [29].

Logistic regression models were established to determine the socioeconomic characteristics of cancer patients associated with post-treatment household impoverishment after adjustment for variations in other variables. An enter approach was adopted in the modelling involving the independent variables with a significant association with post-treatment impoverishment in the univariate analyses. Collinearity of the independent variables was tested through correlation analyses and the variance inflation factor (VIF) (Supplementary Table S3 and Table S4).

Sensitivity tests were performed by comparing the results between the self-respondents and those from the caregivers.

The statistical analyses were performed using Excel 2010 and IBM SPSS Statistics v22. A p value less than 0.05 was considered statistically significant.

Results

A total of 4874 cancer patient records were extracted from the participating hospitals and 2565 patients were followed up. This resulted in a final sample size of 2534 for data analyses after excluding incomplete questionnaires.

Characteristics of respondents

The respondents had an average age of 59 years (Standard Deviation = 13). About 58% were female. More than 85% came from the central (developing) and western (under-developed) regions. Less than half completed higher than senior high school education. The majority (88%) were married; 70% lived in an urban community; and nearly 50% were covered by BMIUE. About 30% engaged in farming. Lung, breast, colorectum, esophagus, liver, and stomach cancers accounted for 70% of the total cases (Table 1).

7

Table 1. Characteristics of study participants and post-treatment impoverishment

Characteristics	Sample size N (%)		Household consumption below China's poverty line US$1.2			Household consumption below global poverty line US$1.9		
			Number	%	p*	Number	%	p*
Gender					0.170			0.072
Male	1076	(42.46)	91	8.46		191	17.75	
Female	1458	(57.54)	102	7.00		220	15.09	
Age (years)					<0.001			<0.001
≤49	665	(26.24)	24	3.61		56	8.42	
50-69	1403	(55.37)	122	8.70		268	19.10	
≥70	466	(18.39)	47	10.09		87	18.67	
Education					<0.001			<0.001
≤ Junior high school	1392	(54.93)	149	10.70		301	21.62	
Senior high school	609	(24.03)	32	5.25		75	12.32	
≥ University	533	(21.04)	12	2.25		35	6.57	
Occupation					<0.001			<0.001
Public employee	267	(10.54)	10	3.75		25	9.36	
Commercial employee	288	(11.37)	12	4.17		25	8.68	
Peasant	745	(29.40)	118	15.84		230	30.87	
Others	1234	(48.70)	53	4.29		131	10.62	
Marital status					0.513			0.292
Unmarried	52	(2.05)	2	3.85		6	11.54	
Married	2224	(87.77)	172	7.73		370	16.64	
Others	258	(10.18)	19	7.36		35	13.57	
Site of cancer					0.002			<0.001
Lung	469	(18.51)	50	10.66		98	20.90	
Breast	637	(25.14)	33	5.18		84	13.19	
Colorectum	266	(10.50)	18	6.77		42	15.79	
Esophagus	86	(3.39)	11	12.79		25	29.07	
Liver	110	(4.34)	8	7.27		19	17.27	
Stomach	200	(7.89)	24	12.00		46	23.00	
Others	766	(30.23)	49	6.40		97	12.66	
Cancer stage					*0.181*			*0.659*
I	453	17.88	26	5.74		75	16.56	
II	476	18.78	34	7.14		71	14.92	
III	402	15.86	29	7.21		65	16.17	
IV	295	11.64	20	6.78		42	14.24	
Unclear	908	35.83	84	9.25		158	17.40	
Residency					<0.001			<0.001
Urban	1737	(68.55)	89	5.12		188	10.82	
Rural	797	(31.45)	104	13.05		223	27.98	
Region					<0.001			<0.001
Eastern	370	(14.60)	11	2.97		28	7.57	
Central	1088	(42.94)	108	9.93		207	19.03	
Western	1076	(42.46)	74	6.88		176	16.36	
Insurance					<0.001			<0.001
BMIUE	1210	(47.75)	37	3.06		102	8.43	
BMIUR	335	(13.22)	25	7.46		46	13.73	
NCMS	789	(31.14)	104	13.18		223	28.26	
Others	200	(7.89)	27	13.50		40	20.00	
Household income					<0.001			<0.001
Quintile 1 (Bottom 20%)	508	(20.05)	132	25.98		241	47.44	
Quintile 2	507	(20.01)	30	5.92		80	15.78	
Quintile 3	506	(19.97)	15	2.96		47	9.29	
Quintile 4	505	(19.93)	12	2.38		27	5.35	
Quintile 5 (Top 20%)	508	(20.05)	4	0.79		16	3.15	

Note: *: χ^2 tests; BMIUE – Basic Medical Insurance for Urban Employees; BMIUR: Basic Medical Insurance for Urban Residents; NCMS – Rural New Cooperative Medical Scheme

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Incidence of household impoverishment

In 2015, China reported 3.95 million new cases of cancer: 40% from rural. Almost half (48%) were reported from the eastern zone (Supplementary Table S5).

Prior to cancer treatment, 0.10% and 0.49% of the households were impoverished according to the Chinese poverty line and the global poverty line, respectively. These figures increased to 5.89% and 12.94%, respectively, after cancer treatment (Table 2, Figure 1, Figure 2).

There was an increase of 5.79% households living in poverty after cancer treatment according to the Chinese poverty line. This amounted to 220,978 households. These figures increased to 12.45% and 475,333 households using the global poverty line. The chance of falling into poverty after cancer treatment in rural residents was almost three times of those living in an urban community. Those living in the less developed western and central regions were also two or three times more likely to experience household impoverishment resulting from cancer treatment compared with their more developed eastern counterparts. Rural households and those living in the central region had the biggest increase in impoverishment resulting from cancer treatment (Table 2).

9

Table 2. Household impoverishment induced by cancer treatment

Households	Percentage (number) of households below CPL US$1.2				Percentage (number) of households below WBPL US$1.9			
	Pre-treatment	Post-treatment	Pre-post difference	Estimates of impoverishment induced by cancer treatment in China	Pre-treatment	Post-treatment	Pre-post difference	Estimates of impoverishment induced by cancer treatment in China
Total	0.10 (4)	5.89 (193)	5.79 (189)	5.79(220978)	0.49 (20)	12.94 (411)	12.45 (391)	12.45(475333)
Rural	0.00 (0)	13.05 (104)	13.05 (104)		1.76 (14)	27.98 (223)	26.22 (209)	
Urban	0.23 (4)	5.12 (89)	4.89 (85)		0.35 (6)	10.82 (188)	10.48 (182)	
Eastern	0.00 (0)	2.97 (11)	2.97 (11)	2.97(53989)	0.00 (0)	7.57 (28)	7.57 (28)	7.57(137609)
Central	0.28 (3)	9.93 (108)	9.65 (105)	9.65(104936)	1.10 (12)	19.03 (207)	17.93 (195)	17.93(194973)
Western	0.09 (1)	6.88 (74)	6.79 (73)	6.79(62054)	0.74 (8)	16.36 (176)	15.62 (168)	15.62(142750)

10

Older patients were more likely to experience post-treatment household impoverishment than their younger counterparts ($p<0.001$). Peasants and those who received lower levels of education were more likely to be impoverished than others ($p<0.001$). Higher incidence of post-treatment household impoverishment was found in the respondents with lung, esophagus, and stomach cancers ($p<0.001$). There existed significant regional and wealth-related disparities in incidence of post-treatment household impoverishment. The patients who lived in the less developed central and western regions, had a rural residency, and enrolled with the less generous NCMS had a higher incidence of post-treatment household impoverishment than others ($p<0.001$). The lowest quintile of income group had 25.98% incidence of post-treatment household impoverishment, compared with less than 6% incidence of the other income groups ($p<0.001$). No significant differences were found in incidence of post-treatment household impoverishment across gender, marital status, and stages of cancer (Table 1).

Socioeconomic inequalities in household impoverishment

The households with the lowest quintile of income were hardest hit by cancer treatment, with 25.39% households falling into poverty under the Chinese line as a result of cancer treatment compared with 44.49% under the global poverty line. These figures were at least four times higher than those of the households with higher income. Inequalities in financial protection functions of the social health insurance programs were evident. The rural patients enrolled with NCMS had similar levels of incidence of household impoverishment as compared with those without a coverage of any of the social health insurance programs, much higher than those covered by the two urban insurance programs BMIUE and BMIUR (Table 3).

Table 3. Inequality in household impoverishment induced by cancer treatment

Characteristics of cancer patients	Percentage (number) of households below CPL US$1.2			Percentage (number) of households below WBPL US$1.9		
	Pre-treatment	Post-treatment	Pre-post difference	Pre-treatment	Post-treatment	Pre-post difference
Health insurance						
BMIUE	0.17 (2)	3.06 (37)	2.89 (35)	0.25 (3)	8.43 (102)	8.18 (99)
BMIUR	0.60 (2)	7.46 (25)	6.87 (23)	0.60 (2)	13.73 (46)	13.13 (44)
NCMS	0.00 (0)	13.18 (104)	13.18 (104)	1.77 (14)	28.26 (223)	26.49 (209)
Others	0.00(0)	13.50 (27)	13.50(27)	0.50(1)	20.00(40)	19.50 (39)
Household income						
Quintile 1 (Bottom 20%)	0.59 (3)	25.98 (132)	25.39 (129)	2.95 (15)	47.44 (241)	44.49 (226)
Quintile 2	0.20 (1)	5.92 (30)	5.72 (29)	0.99 (5)	15.78 (80)	14.79 (75)
Quintile 3	0.00 (0)	2.96 (15)	2.96 (15)	0.00 (0)	9.29 (47)	9.29 (47)
Quintile 4	0.00 (0)	2.38 (12)	2.38 (12)	0.00 (0)	5.35 (27)	5.35 (27)
Quintile 5 (Top 20%)	0.00 (0)	0.79 (4)	0.79 (4)	0.00 (0)	3.15 (16)	3.15 (16)

11

The logistic regression model showed that the incidence of post-treatment household impoverishment was associated with age, site of cancer, region, social health insurance, and household income after adjustment for variations in other variables. The incidence of post-treatment household impoverishment increased with age. The patients with breast cancer had lower odds (AOR=0.538, p=0.014) of experiencing post-treatment household impoverishment than those with lung cancer. The odds of the households in the central region (AOR=2.619, p=0.006) experiencing post-treatment household impoverishment more than doubled that in the most developed eastern region. Significant lower odds (p<0.001) of post-treatment household impoverishment were found in the households with higher income compared with those in the lowest quintile of income group. The patients without a coverage of any of the three social health insurance had higher odds (AOR=1.880, p=0.040) of experiencing post-treatment household impoverishment than those enrolled with BMIUE (Table 4). Further analyses indicated that the regional effect had limited interactions, if any, with the effect of urban-rural residency. The correlation between regional zones and urban-rural residency was weak (<0.21) as indicated by the ecoefficiencies of contingency, phi and Cramer's v, albeit a statistically significant difference in χ^2 test (Supplementary Table S3). No significant multicollinearity was identified in the multivariate modelling (Supplementary Table S4). Reginal differences in post-treatment household impoverishment remained in the sample excluding rural participants (Supplementary Table S6).

12

Table 4. Logistic regression analysis on predictors of the incidence of post-treatment impoverishment in cancer patients

Characteristics of cancer patients	Crude Odds Ratio (95%CI)	p	Adjusted Odds Ratio (95%CI)*	p
Age (years)				
≤49	1 (reference)		1 (reference)	
50-69	2.544 (1.625-3.981)	<0.001	2.666 (1.659-4.285)	<0.001
≥70	2.996 (1.805-4.974)	<0.001	4.187 (2.400-7.305)	<0.001
Educational attainment				
≤ Junior high school	1 (reference)		1 (reference)	
Senior high school	0.463 (0.312-0.686)	<0.001	0.987 (0.637-1.530)	0.955
≥ University	0.192 (0.106-0.349)	<0.001	1.166 (0.572-2.376)	0.673
Occupation				
Public employee	1 (reference)		1 (reference)	
Commercial employee	1.117 (0.475-2.631)	0.799	0.731 (0.287-1.864)	0.511
Peasant	4.837 (2.496-9.373)	<0.001	0.818 (0.341-1.964)	0.653
Others	1.153 (0.579-2.297)	0.685	0.597 (0.271-1.316)	0.201
Site of cancer				
Lung	1 (reference)	0.002	1 (reference)	
Breast	0.458 (0.290-0.723)	0.001	0.538 (0.328-0.882)	0.014
Colorectum	0.608 (0.347-1.066)	0.082	0.624 (0.342-1.140)	0.125
Esophagus	1.229 (0.612-2.469)	0.562	0.703 (0.328-1.504)	0.363
Liver	0.657 (0.302-1.430)	0.290	0.830 (0.362-1.903)	0.660
Stomach	1.143 (0.681-1.917)	0.613	0.818 (0.463-1.444)	0.488
Others	0.573 (0.379-0.865)	0.008	0.513 (0.324-0.814)	0.005
Residency				
Urban	1 (reference)		1 (reference)	
Rural	2.779 (2.066-3.738)	<0.001	0.993 (0.692-1.425)	0.970
Region				
Eastern	1 (reference)		1 (reference)	
Central	3.597 (1.912-6.767)	<0.001	2.619 (1.317-5.206)	0.006
Western	2.410 (1.265-4.593)	0.007	1.535 (0.766-3.076)	0.227
Health insurance				
BMIUE	1 (reference)		1 (reference)	
BMIUR	2.557 (1.516-4.312)	<0.001	1.225 (0.683-2.195)	0.496
NCMS	4.813 (3.269-7.087)	<0.001	1.355 (0.827-2.219)	0.228
Others	4.948 (2.938-8.332)	<0.001	1.880 (1.030-3.431)	0.040
Household income				
Quintile 1 (Bottom 20%)	1 (reference)		1 (reference)	
Quintile 2	0.179 (0.118-0.272)	<0.001	0.187 (0.121-0.288)	<0.001
Quintile 3	0.087 (0.050-0.151)	<0.001	0.094 (0.052-0.171)	<0.001
Quintile 4	0.069 (0.038-0.127)	<0.001	0.072 (0.037-0.142)	<0.001
Quintile 5 (Top 20%)	0.023 (0.008-0.062)	<0.001	0.024 (0.008-0.070)	<0.001

Note:∗ R^2 of Cox & Snell=0.104；R^2 of Nagelkerke=0.249；R^2 of McFadden=0.203

The median consumption gap accumulated by the impoverished households post cancer treatment reached US$128 per capita per year underneath the CPL and US$212 per capita per year underneath the WBPL, respectively. These amounted to a total of US$31 million (under CPL) and US$115 million (under WBPL) needed to avoid household impoverishment induced by cancer treatment. The impoverished households with the lowest quintile of income also accumulated twice or tripled

13

consumption gaps underneath the poverty line in comparison with their wealthiest counterpart (Supplementary Table S7).

Discussion

This study presents new evidence on household impoverishment induced by cancer treatment in China. About 5.79% of households became impoverished according to the CPL after paying for cancer treatment out of pocket. This figure would increase to 12.45% using the WBPL. Such an incidence appears to be low compared with findings of studies conducted in some other developing countries [11]. The interpretation of the comparative results needs to be cautious. In this study and others undertaken in China [30], indirect costs associated with medical services such as transportation, foods, and out-of-hospital accommodations were not included in the estimation of costs for cancer treatment. This may have deflated the real financial burden of cancer treatment in China.

The social health insurance programs have limited effects on preventing household impoverishment induced by cancer treatment. Although patients without a coverage of any of the three social health insurance programs are more likely to experience post-treatment household impoverishment than those enrolled with BMIUE, significant increases in household impoverishment after cancer treatment occurred in enrollees of all the three insurance programs. Patients covered by NCMS appear to have the same chance of falling into poverty as those without coverage of any of the social health insurance programs. Previous studies found that funding available for NCMS enrollees is only about half of that for BMIUE enrollees [31]. Empirical evidence shows that public financing is effective in protecting the most vulnerable populations from medical-induced poverty [32-34]. However, this requires well targeted investments (the so-called precision poverty alleviation) [35]. This study estimates that at least 31 million US dollars will be needed annually to alleviate the impoverishment induced by cancer treatment according to the CPL, or 115 million US dollars according to the WBPL. Previous studies showed that BMIUE had the highest level of compensation rates and the lowest OOP requirements in comparison with the other two schemes [23, 36]. The average payments from the insurance programs for hospital admitted patients were estimated to be around 68% for BMIUE, 48% for BMIUR and 44% for NCMS in 2011 [23]. The eastern region offered a higher level of compensations. In Suzhou, for example, 73%, 71% and 56% of hospital charges were covered by BMIUE, BMIUR and NCMS, respectively in 2014 [36]. Under-the-table user fees were nominal, if ever existed, due to strict regulations.

Socioeconomic inequality in household impoverishment resulting from cancer treatment in China deserves increasing policy attention. This study found that inequalities exist from a range of perspectives: (1) Households with the lowest quintile of income stand at least four times higher chance of falling into poverty after cancer treatment than the richer ones: more than one quarter of them became impoverished under the Chinese poverty line or almost 45% under the global poverty line. These results are consistent with findings of other studies [37-39]. (2) Rural households have tripled incidence of impoverishment induced by cancer treatment

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compared with the urban ones. The urban-rural inequality is likely to be a result of income disparities [40] and disparities in primary care services [41, 42]. The urban-rural difference in incidence of post-treatment household impoverishment disappeared after adjustment for variations in other variables. (3) Like findings of previous studies [11], older people were found in this study to suffer more from household impoverishment as a result of cancer treatment. (4) Significant regional disparities exist. Although it is certain that the most developed eastern region is better off, the central developing region suffers more than the poorest western region. In 2015, disposable income of the central region averaged at US$2961 per capita, compared with US$4531 in the eastern and US$2708 in the western region [43]. However, the national government of China has provided significantly more financial subsidies to the western region than to the central region. Previous studies also show that patients from the central region are more likely to seek more expensive medical services compared with their western counterparts due to higher financial capability, convenience of transportation and better accessibility to high medical technologies [44].

It is important to note that accessibility to healthcare services can be seriously jeopodized by low household income especially in a system that requires high proportions of out of pocket payments [45]. This study showed an absence of pre-treatment household impoverishment for rural residents. Empirical evidence shows that some households with low income are likely to forfeit expensive medical care including cancer treatment to avoid impoverishment [46]. The actual scale of household impoverishment would be higher should all cancer cases are treated in line with relevant clinical guidelines. Indeed, low household income may suppress the spending of medical care despite wide coverage of health insurance according to the findings of this study.

Findings of this study have some policy implications. The current health insurance programs in China are highly fragmented. A better coordinated effort is needed to address the inequality in household impoverishment induced by cancer treatment. This can start from a national central cancer registry system and share of insurance claim data given that the national government of China has been increasing its investments in social health insurance, health services delivery, and medical assistance (to help poor households to enroll with social health insurance and pay for OOP expenses) programs. Government investments need to be channeled to those most in need [47]. The role of primary care in managing cancer patients should also be strengthened.

This study has several limitations. Firstly, data in this study were collected through questionnaire survey, which are subject to recall bias. The sensitivity test indicates that patient estimation of household consumption is significantly higher than that from the caregivers (supplementary Table S1). Secondly, the stratified sampling strategy adopted in this study ensured that the minimal sample size could be met in all of the three regions. However, the more populated eastern region was under-represented. Thirdly, non-medical costs like travel were excluded in this study. The financial sources of household consumption were unknown. Some households were likely to

15

borrow money to pay for the consumptions. Household impoverishment was determined by daily consumption in this study, which is a widely accepted approach. However, we did not examine the source of income for household consumptions. If some households borrowed money or realized assets to pay for daily consumption, this could lead to potential underestimation of household impoverishment. Further studies are needed to examine whether income falls post treatment (people losing their jobs), which categories of consumption are most impacted by cancer treatment spending, and where households are deciding to cut costs.

Conclusion

The financial burden of cancer treatment imposes a significant risk of household impoverishment in China despite an almost universal coverage of social health insurance. The risk falls disproportionally onto the households living with low income. Significant socioeconomic inequalities exist in household impoverishment resulting from cancer treatment. Unbalanced regional development and fragmentation of health insurance programs may have jeopardized the efforts in alleviating poverty induced by medical services.

Abbreviation list

CPL: Chinese poverty line;

WBPL: World Bank poverty line;

OOP: out-of-pocket payment;

BMIUE: basic medical insurance for urban employees;

BMIUR: basic medical insurance for urban resident;

NCMS: rural new cooperative medical scheme

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Footnotes

Contributors

GL, JS, WF, ZX, CL, LL, MZ, LY, BB, SC, YZ DW, NL, WC, MD and JH designed the study, implemented the survey and collected data. GL, CJL, WF, CS, YD and HW analyzed the data. WF and CJL prepared the manuscript. All the authors read and approved the final version of the manuscript.

18

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Patient and public involvement statement: Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Figure legends

Figure 1

Title: Pen's Parade of impoverished households before and after cancer treatment

Horizontal axis : Cum % of pop, ranked by consumption per capita

Vertical axis: Consumption per capita (US$)

Legends: Blue line: Pre-treatment

Red line: Post-treatment

Figure 2

Title: Pen's Parade of impoverished households before and after cancer treatment (in view of the bottom 20%)

Horizontal axis : Cum % of pop, ranked by consumption per capita

Vertical axis: Consumption per capita (US$)

Legends: Blue line: Pre-treatment

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Red line: Post-treatment

‐‐‐ : China's poverty line

……… : Global poverty line

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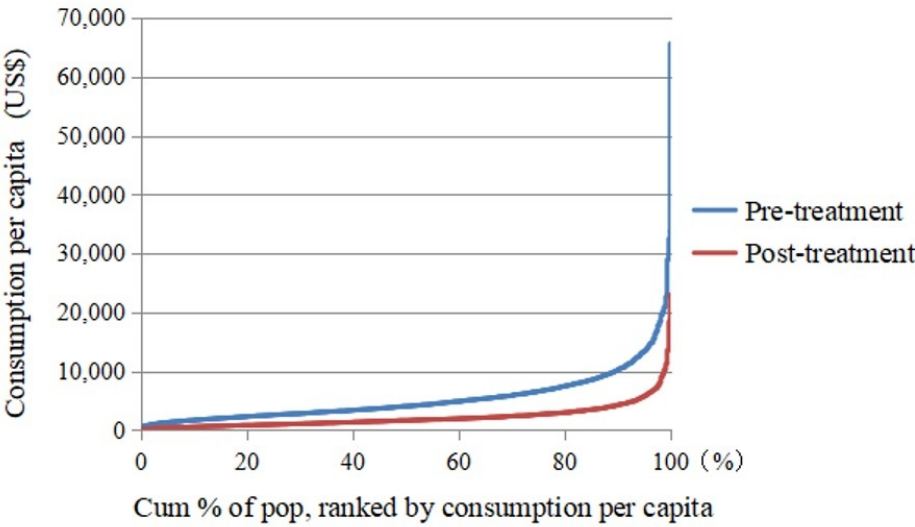53
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Figure 1. Pen's Parade of impoverished households before and after cancer treatment
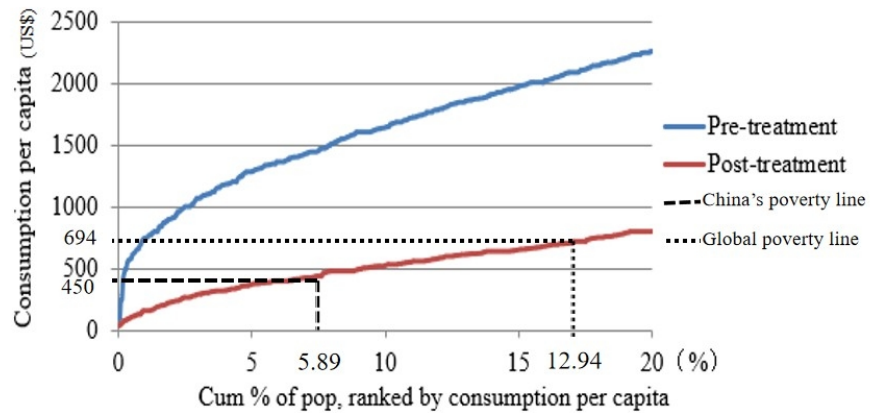
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Figure 2. Pen's Parade of impoverished households before and after cancer treatment (in view of the bottom 20%)

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Supplementary File

Table S1. Household consumption per capita pre- and post-treatment by respondents (patients vs caregivers)

	Sample size N (%)		Consumption per capita pre-treatment					Consumption per capita post-treatment				
	Patients N (%)	Caregivers N (%)	Overall Median (P25, P75)	Patients Median (P25, P75)	Caregivers Median (P25, P75)	χ^2	P	Overall Median (P25, P75)	Patients Median (P25, P75)	Caregivers Median (P25, P75)	χ^2	P
Total	1334 (52.6%)	1200 (47.4%)	4014 (2601,6538)	4431 (2890,7064)	3506 (2316,6021)	39.70	0.00	1606 (902,2622)	1782 (1020,3024)	1445 (813,2200)	40.82	0.00
Residency												
Urban	965 (55.6%)	772 (44.4%)	4359 (2810,6952)	4774 (3067,7432)	3934 (2569,6422)	18.29	0.00	1846 (1124,2946)	2042 (1284,3436)	1670 (1017,2438)	31.19	0.00
Rural	369 (46.3%)	428 (53.7%)	3350 (2197,5374)	3746 (2447,5748)	2953 (2007,5139)	18.45	0.00	1069 (642,1789)	1190 (692,1959)	1029 (618,1684)	4.68	0.03
Region												
Eastern	293 (79.2%)	77 (20.8%)	6007 (4041,9280)	6061 (4172,9505)	5460 (3547,9152)	0.26	0.61	2456 (1400,4174)	2729 (1461,4292)	1827 (1127,2826)	5.31	0.02
Central	589 (54.1%)	499 (45.9%)	3615 (2328,6128)	3853 (2515,6255)	3340 (2143,6021)	6.53	0.01	1445 (803,2155)	1498 (835,2256)	1365 (803,1991)	4.11	0.04
Western	452 (42%)	624 (58%)	3744 (2531,6021)	4173 (2912,6506)	3465 (2360,5534)	16.12	0.00	1646 (913,2613)	1906 (1109,3183)	1445 (816,2284)	24.32	0.00
Insurance												
BMIUE	689 (56.9%)	521 (43.1%)	4629 (2935,7172)	4957 (3211,7626)	4137 (2649,6543)	9.83	0.00	2007 (1284,3199)	2208 (1440,3546)	1782 (1070,2569)	25.25	0.00
BMIUR	174 (51.9%)	161 (48.1%)	4014 (2703,6636)	3988 (2649,6636)	4014 (2810,6636)	0.00	0.97	1606 (963,2529)	1606 (963,2729)	1517 (978,2380)	0.57	0.45
NCMS	366 (46.4%)	423 (53.6%)	3333 (2188,5374)	3746 (2447,5994)	2904 (2007,5137)	19.25	0.00	1073 (642,1798)	1189 (690,1965)	1025 (615,1686)	3.84	0.05
Others	105 (52.5%)	95 (47.5%)	3698 (2418,6497)	4957 (3152,7430)	3042 (1741,4785)	23.18	0.00	1565 (803,2376)	1813 (835,3479)	1217 (679,1782)	1.28	0.26
Household income												
Quintile 1 (Bottom 20%)	228 (44.9%)	280 (55.1%)	2721 (1735,4226)	3191 (1950,4717)	2437 (1658,3547)	10.89	0.00	717 (438,1181)	787 (479,1191)	700 (428,1177)	0.96	0.33
Quintile 2	255 (50.3%)	252 (49.7%)	3118 (2167,4710)	3372 (2408,4710)	2893 (1992,4696)	4.00	0.05	1204 (865,1766)	1284 (867,1873)	1134 (863,1625)	5.13	0.02
Quintile 3	272 (53.8%)	234 (46.2%)	3864 (2649,6290)	4108 (2732,6374)	3567 (2569,6116)	2.30	0.13	1646 (1127,2288)	1711 (1199,2408)	1606 (1112,2143)	0.81	0.37
Quintile 4	287 (56.8%)	218 (43.2%)	4817 (3235,7474)	5057 (3527,7787)	4469 (2855,7084)	3.04	0.08	2141 (1373,2950)	2256 (1606,3372)	1833 (1188,2574)	8.71	0.00
Quintile 5 (Top 20%)	292 (57.5%)	216 (42.5%)	6422 (4541,9500)	6816 (5029,9966)	5871 (3948,8590)	10.88	0.00	3211 (1999,4926)	3612 (2408,5683)	2477 (1816,4034)	31.51	0.00

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Table S2. Items measuring household income, consumption and out of pocket payment for cancer treatment

Household income
Covered
Wage
Non-wage: return on capital investments, dividends, interests, governmental subsidies
Self-employed income
Property income
Supportive income: pension paid to parents by children
Gift
Not-covered
Personal secret income of unknown origin, not recorded, tax evasion, undeclared
Household Consumption
Covered
Foods
Clothing
Daily necessities
Transportation
Communication
Housing mortgage or rent
Utility: Water, electricity and gas
Education
Medical care (drugs, services and supplies)
Insurance
Cultural activities
Entertainment activities
Not-covered
Capital investments and repairments
Other profit generating investment activities
Out of pocket payments for cancer treatment
Covered
Hospital services
Medicine
Not-covered
Insurance reimbursement for medical expenditure
Transportation
Out of hospital accommodations
Meals
Nutrients
Informal caregivers

Table S3. Correlation between region and urban/rural residency in respondents

	Eastern		Central		Western		Pearson χ^{2*}	Contingency Coefficient[*]	Phi Coefficient[*]	Cramer's V[*]	Lambda[*]
	N	(%)	N	(%)	N	(%)					
Total	370	(100.00)	1088	(100.00)	1076	(100.00)	108.389	0.203	0.207	0.207	0.099
Urban	256	(69.19)	857	(78.77)	624	(57.99)					
Rural	114	(30.81)	231	(21.23)	452	(42.01)					

Note: *P<0. 001

Table S4. Collinearity diagnosis results

	Tolerance	VIF
Age (years)	0.87	1.15
Educational attainment	0.64	1.56
Occupation	0.94	1.07
Site of cancer	0.95	1.05
Residency	0.50	2.00
Region	0.90	1.11
Health insurance	0.50	2.00
Household income	0.65	1.53

Table S5. New cases of cancer recorded in China, 2015

Location	No. population (100,000)[*]	Incidence (per 100,000 population)[**]	Number (percentage) of cases
Total	13,746	288	3,953,957 (100%)
Residency			
Rural	6,035	267	1,608,221 (40%)
Urban	7,712	311	2,394,606 (60%)
Region			
Eastern	5,690	319	1,817,816 (48%)
Central	4,305	253	1,087,415 (28%)
Western	3,751	244	913,896 (24%)

Source of data: * National Bureau of Statistics of China. China Statistical Yearbook 2015. China Statistics Press;

** National Cancer Center. China Cancer Registry Annual Report 2018. People's Medical Publishing House

Table S6. Regional differences in urban household impoverishment post cancer treatment

	Sample size	Household consumption below CPL US$1.2		Household consumption below WBPL US$1.9		χ^2	P
	N (%)	number	%	number	%		
Total	1737 (100.00)	89	5.1	188	10.8	15.784	0.000
Eastern	256 (14.74)	4	1.6	10	3.9		
Central	857 (49.34)	61	7.1	121	14.1		
Western	624 (35.92)	24	3.8	57	9.1		

Table S7. Accumulated consumption gap post cancer treatment in impoverished households in China

Characteristics of cancer patients	Total (median) Annual US$ gap per capita		Estimates of impoverishment induced by cancer treatment in China	
	Households below China's poverty line US$1.2	Households below global poverty line US$1.9	Households below China's poverty line US$1.2	Households below global poverty line US$1.9
Total	27,488 (128)	91,081 (212)	31,170,395	115,238,459
Region				
East	1,266 (71)	6,108 (220)	6,221,542	30,010,513
Midland	15,616 (134)	48,746 (212)	15,777,767	52,298,712
West	10,605 (122)	36,226 (182)	9,171,086	32,929,233
Residency				
Rural	15179 (127)	48080 (212)		
Urban	12308 (128)	43001 (212)		
Health insurance				
UEBMI	5,699 (128)	21,245 (172)		
URBMI	2,589 (91)	10,201 (255)		
NCMS	15,179 (127)	48,080 (212)		
Others	4,019 (148)	11,555 (292)		
Household income				
Quintile 1 (Bottom 20%)	19,020 (132)	58,289 (256)		
Quintile 2	4,451 (112)	14,997 (185)		
Quintile 3	1,698 (82)	8,713 (148)		
Quintile 4	2,110 (150)	6,307 (158)		
Quintile 5 (Top 20%)	209 (44)	2,774 (153)		

**Effects of cancer treatment on household impoverishment:
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Complete List of Authors:	Fu, Wenqi; Harbin Medical University, School of Health Management / Public Health Shi, Jufang; Chinese Academy of Medical Sciences and Peking Union Medical College, Office of Cancer Screening, National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital; zhang, xin; Harbin Medical University, School of Health Management / Public Health Liu, Chengcheng; Chinese Academy of Medical Sciences and Peking Union Medical College, Office of Cancer Screening / National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital Sun, Chengyao; Harbin Medical University, School of Health Management / Public Health Du, Yupeng; Harbin Medical University, School of Health Management / Public Health Wang, Hong; Harbin Medical University, School of Health Management / Public Health Liu, Chaojie; La Trobe University, School of Psychology and Public Health, Lan, Li; Harbin center for disease control and prevention, Institute for Prevention and Control of Chronic Non-communicable Diseases Zhao, Min; Yunnan Provincial Cancer Hospita, Department of Medical Administration Yang, Li; Guangxi Medical University, School of Public Health Bao, Burenbatu; Affiliated Hospital of Inner Mongolia University for Nationalities, Department of Hematology and oncology Cao, Sumei; Sun Yat-sen University Cancer Center, Department of Cancer Prevention Zhang, Yongzhen; Shanxi Provincial Cancer Hospital, Department of Epidemiology Wang, DeBin; Anhui Medical University, Health Management College Li, Ni; Chinese Academy of Medical Sciences and Peking Union Medical College, Office of Cancer Screening / National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital Chen, Wanqing; Chinese Academy of Medical Sciences and Peking Union Medical College, Office of Cancer Screening, National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital Dai, Min; Chinese Academy of Medical Sciences and Peking Union Medical College, Office of Cancer Screening, National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital Liu, Guoxiang; Harbin Medical University, School of Health Management / Public Health

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Effects of cancer treatment on household impoverishment: a multicenter cross-sectional study in China

Wenqi Fu,[a],* Jufang Shi,[b],* Xin Zhang,[a] Chengcheng Liu,[b] Chengyao Sun,[a] Yupeng Du,[a] Hong Wang,[a] Chaojie Liu,[c] Li Lan,[d] Min Zhao,[e] Li Yang,[f] Burenbatu Bao,[g] Sumei Cao,[h] Yongzhen Zhang,[i] Debin Wang,[j] Ni Li,[b] Wanqing Chen,[b] Min Dai,[b] Guoxiang Liu,[a] Jie He[b]

*Contributed equally to this work.

Correspondence to: Guoxiang Liu, lgx6301@163.com; Wanqing Chen, chenwq@cicams.ac.cn

[a] School of Health Management / Public Health, Harbin Medical University, Harbin 150081, China

[b] Office of Cancer Screening, National Cancer Center / National Clinical Research Center for Cancer / Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing 100021, China

[c] School of Psychology and Public Health, La Trobe University, Melbourne VIC 3086, Australia

[d] Institute for Prevention and Control of Chronic Non-communicable Diseases, Harbin Center for Disease Control and Prevention, Harbin, 150056, China

[e] Department of Medical Administration, Yunnan Provincial Cancer Hospital, Kunming 650118, China

[f] School of Public Health, Guangxi Medical University 530021, China

[g] Department of Hematology and oncology, Affiliated Hospital of Inner Mongolia University for Nationalities, Tongliao, 028050, China

[h] Department of Cancer Prevention, Sun Yat-sen University Cancer Center, Guangzhou, 510060, China

[i] Department of Epidemiology, Shanxi Provincial Cancer Hospital, Taiyuan, 030013, China

[j] Health Management College, Anhui Medical University, Hefei 230032, China

Abstract

1

Objectives: to determine the incidence and intensity of household impoverishment induced by cancer treatment in China.

Design: Average income and daily consumption per capita of the households and out-of-pocket payments for cancer care were estimated. Household impoverishment was determined by comparing per capita daily consumption against the Chinese poverty line (CPL, US$1.2) and the World Bank poverty line (WBPL, US$1.9) for 2015. Both pre-treatment and post-treatment consumptions were calculated assuming that the households would divert daily consumption money to pay for cancer treatment.

Participants: Cancer patients diagnosed initially from 01 January 2015 to 31 December 2016 who had received cancer treatment subsequently. Those with multiple cancer diagnoses were excluded.

Data sources: A household questionnaire survey was conducted on 2534 cancer patients selected from nine hospitals in seven provinces through two-stage cluster/convenience sampling.

Findings: 5.89% (CPL) to 12.94% (WBPL) households were impoverished after paying for cancer treatment. The adjusted odds ratio (AOR) of post-treatment impoverishment was higher for older patients (AOR=2.666-4.187 for $\geq$50 years vs <50 years, p<0.001), those resided in central region (AOR=2.619 vs eastern, p<0.01), and those with lower income (AOR=0.024-0.187 in higher income households vs the lowest 20%, p<0.001). The patients without coverage from social health insurance had higher odds (AOR=1.880, p=0.040) of experiencing post-treatment household impoverishment than those enrolled with the insurance for urban employees. Cancer treatment is associated with an increase of 5.79% (CPL) and 12.45% (WBPL) in incidence of household impoverishment. The median annual consumption gap per capita underneath the poverty line accumulated by the impoverished households reached US$128 (CPL) or US$212 (WBPL). US$31,170,395 (CPL) or US$115,238,459 (WBPL) were needed to avoid household impoverishment induced by cancer treatment in China.

Conclusions: The financial burden of cancer treatment imposes a significant risk of household impoverishment despite wide coverage of social health insurance in China.

Keywords: Household impoverishment; Cancer; Out-of-pocket payment; China

Strengths and limitations of this study

- This is one of the few studies involving a large sample of cancer patients in China.

- Household impoverishment induced by cancer treatment was estimated, including its socioeconomic inequalities.

- National funds required for alleviating household impoverishment induced by cancer treatment were estimated based on new cases of cancer diagnosis.

- Patients with multiple cancer diagnoses were excluded from the study.

2

- Data were collected through a questionnaire survey, which are subject to recall bias.

Introduction

Cancer causes enormous physical and mental harm on patients and their families [1]. In 2012, 14.1 million new cases of cancer were reported in the world and 8.2 million cancer patients died. These figures surged to 18.1 million and 9.6 million, respectively, in 2018 [2, 3]. A further 75% increase in new cases of cancer over the next two decades is anticipated [4]. China bears the highest burden of cancer, ranking on top of the world not only in absolute numbers and deaths but also in proportion to the population size [4]. It was estimated that 4.3 million new cancer cases were diagnosed and 2.8 million died from cancer in China in 2015 [5]. Cancer has become the leading cause of death in China. The rising trend of cancer shows no sign of containment [6].

The costs of cancer treatment put a great financial stress on cancer patients and their families. According to the Medical Panel Expenditure Survey, the households with a cancer survivor in the US paid on average US$2304 out of pocket (OOP) every year over the period from 2008 to 2016 [7]. The annual OOP spending on metastatic breast cancer treatment in the US during 2004 to 2011 reached US$6642 [8]. A multicenter cross-sectional survey in China over the period from 2012 to 2014 showed that the OOP spending of cancer treatment in the first year averaged at US$4947, which equaled to 57.5% of the average annual household income. About 77.6% of the households with a cancer patient experienced unmanageable financial difficulties [9].

The high cost of cancer treatment has imposed disproportional burdens on the households living with low income. They are more prone to falling into impoverishment as a result of OOP payments for cancer treatment. This has prompted the World Health Organization to call for increasing policy attention addressing the inequality issue through a systems approach [10-12]. A study in Heilongjiang, a province ranked in the middle range of economic development in China, showed that as many as 86% of households with a cancer patient could become impoverished as a result of cancer treatment [13].

Health insurance has been widely accepted as an effective strategy to prevent household impoverishment induced by cancer treatment [14]. Although extensive studies have been conducted on the relationship between cancer and poverty [15-18], there is paucity in the literature documenting the situation in low- and middle-income countries [11]. Most low- and middle-income countries cannot afford the same level of insurance entitlements as their high-income counterparts. Internationally, little is known about inequality of household impoverishment resulting from cancer treatment and the role of health insurance in alleviating cancer-induced impoverishment [19].

This study aimed to determine the incidence and intensity of household impoverishment induced by cancer treatment in China. By 2015, more than 95% of Chinese citizens had been covered by social health insurance [20]. However, there have been significant disparities in insurance entitlements across regions, between urban and rural, and across different insurance programs [21]. There are three social health insurance programs subsidized by the government: Basic Medical Insurance for Urban Employees

3

(BMIUE), Basic Medical Insurance for Urban Residents (BMIUR), and the New Cooperative Medical Scheme (NCMS). The BMIUE was initiated in 1998 with premium contributions from both employers and employees, covering urban employees and retirees in the formal sector, including those who previously enjoyed free medical care offered by public agencies and state-owned enterprises. Funding resources for the NCMS (initiated in 2003) and BMIUR (initiated in 2007) come from both individual voluntary contributions and local governmental subsides. The former covers rural residents, while the latter covers the urban residents who are not eligible for the BMIUE, such as those self-employed, unemployed, children, and students. All these three programs are managed at the municipal or county level with varied funding pools and benefit policies. The BMIUE enrollees enjoy a relatively higher level of entitlements compared with the other two. Recently, the NCMS and BMIUR started to merge in some regions [20, 22, 23]. There is a shortage of research into the role of these insurance programs in preventing poverty induced by medical care services. The State Council of China made it clear in 2016 that disease-associated poverty would be given priority in the governmental poverty alleviating campaign [24].

Methods

Study design and sites

A multicenter cross-sectional survey was conducted from January 2018 to June 2019 as part of the Cancer Screening Program in Urban China [25]. Geographic regions/provinces were grouped into eastern, central and western in line with the classification of economic development zones by the National Bureau of Statistics. Nine tertiary hospitals were purposively selected from these zones considering cancer patient volumes and completeness of medical records, including Guangdong Cancer Hospital (eastern), Anhui Cancer Hospital, Heilongjiang Cancer Hospital, Shanxi Cancer Hospital (central), Guangxi Cancer Hospital, Yunnan Cancer Hospital, the Regional Cancer Hospital and two city hospitals in Inner Mongolia (western).

Study participants

Cancer patients diagnosed initially over the period from 01 January 2015 to 31 December 2016 were eligible for this study. They had to receive cancer treatment subsequently. Eligible participants were those who had one primary cancer (including metastatic cancer). Those with two or more primary cancer diagnoses were excluded. The eligibility of study participants was assessed through the hospital records. Lung, breast, colorectum, esophageal, liver, and stomach cancers accounted for 70% of the total sample. About 27.50% were diagnosed with a cancer in stage III or stage IV.

Previous study showed that about 20% households with cancer patients might live in poverty. A sample size of 1600 would allow an estimation of the impoverishment rate with 2% precision as α being set at 0.05 [26]. Given the rapid development of social health insurance in recent years, cancer-induced impoverishment may have dropped significantly. We increased the sample size to 2500, with a minimal of 360 patients being contacted in each participating province. In each province, 720 medical records of cancer patients were randomly extracted for the follow-up survey.

4

Outcome Indicators

Impoverished households were identified by assessing household consumption against the poverty line [27]. This included regular and repeated expenses to satisfy the essential needs of household members, which only counted the expenses paid out of pocket, not including those subsidized by the government and insurance. A daily household consumption below US$1.2 per capita per day (US$438 per year) in the 2015 value was deemed impoverishment according to the State Council of China. Globally, poverty line was set at US$1.90 per capita per day (US$694 per year) in the 2015 value by the World Bank [28].

The primary outcome indicators included (1) incidence of household impoverishment as a percentage of households living under the poverty line; and (2) intensity of household impoverishment reflected by the distance of household consumption per capita from the poverty line, which was calculated as the monetary value difference between the poverty line and per capita household consumption after paying for cancer treatment [27].

The marginal contribution of cancer treatment to household impoverishment was calculated as the difference in incidence of household impoverishment pre- and post-cancer treatment. The expenditure associated with cancer diagnosis and treatment was counted as pre-treatment consumption, which was subsequently deprived from post-treatment consumption. The national scale of impoverishment resulting from cancer treatment was estimated based on the number of new cancer cases reported in 2015 across the three regions in China. A weighting system was applied based on the number of new cancer cases in the estimation of national incidence of household impoverishment: 0.48 for eastern, 0.28 for central, and 0.24 for western.

Data Collection

Eligible study participants were identified from the hospital records and then approached for a questionnaire survey. The questionnaire was administered through face-to-face interviews over the period from March to December 2018. The survey was coordinated by the National Cancer Center. The interviewers were trained prior to deployment and required to check completeness of the questionnaire before concluding each interview.

In each household, either the patient or her/his primary family caregiver was invited to respond to the questionnaire. Participation was voluntary. Written informed consent was obtained prior to each interview. Of the returned questionnaires, 53% were completed by the patients, compared with 47% by their family caregivers (Supplementary Table S1). The respondents were asked to estimate OOP payments for cancer treatment over a one-year period (two months before and ten months after diagnosis of the cancer). These included OOP payments for hospital diagnosis and treatment and medicines (both prescribed and non-prescribed) purchased from pharmacy retail outlets.

5

The household income and consumption data covered both 2015 and 2016. Average income and consumption across the two years were calculated to match the cancer treatment cost data due to difficulties to articulate a clear cut-off point for the income and consumption data.

The questionnaire items measuring household income and consumption (Supplementary Table S2) were derived from the National Health Services Survey and the Statistical Bulletin on National Economic and Social Development in China. Income included salary, return on capital investments, dividends and interests, governmental subsidies and gifts. Household consumptions included foods, clothing, daily necessities, transportation, communication, housing (mortgage/rents and utilities), education, medical care, insurance, and cultural and entertainment activities. Capital investments and repairments and other profit generating investment activities were excluded.

In this study, we only estimated direct OOP payments for cancer treatment (Supplementary Table S1). Indirect costs associated with transportation and travel, meals, and informal caregivers were excluded. All of the three social health insurance programs had very detailed descriptions of covered items. The insured patients needed to pay for all of the uncovered items (including some drugs for cancer therapy). On top of that, there were deductible (insurance compensations would start only when medical expenditure exceeded a defined minimal level), copayments (share of fee between insurance and the insured), and ceiling requirements (insurance would stop compensations once the expenses reached a defined maximal level).

Data were double-entered into EpiData 3.1 to ensure accuracy.

Data Analysis

Data about cancer treatment expenditure, household income and consumption were converted to the 2015 value of US dollars (1 USD = 6.2284 Chinese Yuan) for the purpose of assessing impoverishment against the 2015 poverty line set up by the State Council of China and the World Bank.

Pen's Parade graphs were produced to visualize the effect of OOP payments for cancer treatment on household impoverishment. Per-capita household consumptions were plotted along the y-axis against the cumulative percentage of households ranked by per capita household consumptions along the x-axis for pre-treatment and post-treatment, respectively. The graphs give a clear indication on the proportion of households living below the poverty line. The area covered by the parade of those below the poverty line indicates the gap in household consumption that needs to fill up to alleviate poverty [27].

Inequality in household impoverishment induced by cancer treatment was assessed by comparing the pre-post treatment differences in incidence of household impoverishment in patients with different household incomes and insurance coverage. The patients were divided into quintile according to per capita household income [29].

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Logistic regression models were established to determine the socioeconomic characteristics of cancer patients associated with post-treatment household impoverishment after adjustment for variations in other variables. An enter approach was adopted in the modelling involving the independent variables with a significant association with post-treatment impoverishment in the univariate analyses. Collinearity of the independent variables was tested through correlation analyses and the variance inflation factor (VIF) (Supplementary Table S3 and Table S4).

Sensitivity tests were performed by comparing the results between the self-respondents and those from the caregivers.

The statistical analyses were performed using Excel 2010 and IBM SPSS Statistics v22. A *p* value less than 0.05 was considered statistically significant.

Patients and public involvement statement: Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Results

A total of 4874 cancer patient records were extracted from the participating hospitals and 2565 patients were followed up. This resulted in a final sample size of 2534 for data analyses after excluding incomplete questionnaires.

Characteristics of respondents

The respondents had an average age of 59 years (Standard Deviation = 13). About 58% were female. More than 85% came from the central (developing) and western (under-developed) regions. Less than half completed higher than senior high school education. The majority (88%) were married; 70% lived in an urban community; and nearly 50% were covered by BMIUE. About 30% engaged in farming. Lung, breast, colorectum, esophagus, liver, and stomach cancers accounted for 70% of the total cases (Table 1).

7

Table 1. Characteristics of study participants and post-treatment impoverishment

Characteristics	Sample size N (%)		Household consumption below China's poverty line US$1.2			Household consumption below global poverty line US$1.9		
			Number	%	p*	Number	%	p*
Gender					0.170			0.072
Male	1076	(42.46)	91	8.46		191	17.75	
Female	1458	(57.54)	102	7.00		220	15.09	
Age (years)					<0.001			<0.001
≤49	665	(26.24)	24	3.61		56	8.42	
50-69	1403	(55.37)	122	8.70		268	19.10	
≥70	466	(18.39)	47	10.09		87	18.67	
Education					<0.001			<0.001
≤ Junior high school	1392	(54.93)	149	10.70		301	21.62	
Senior high school	609	(24.03)	32	5.25		75	12.32	
≥ University	533	(21.04)	12	2.25		35	6.57	
Occupation					<0.001			<0.001
Public employee	267	(10.54)	10	3.75		25	9.36	
Commercial employee	288	(11.37)	12	4.17		25	8.68	
Peasant	745	(29.40)	118	15.84		230	30.87	
Others	1234	(48.70)	53	4.29		131	10.62	
Marital status					0.513			0.292
Unmarried	52	(2.05)	2	3.85		6	11.54	
Married	2224	(87.77)	172	7.73		370	16.64	
Others	258	(10.18)	19	7.36		35	13.57	
Site of cancer					0.002			<0.001
Lung	469	(18.51)	50	10.66		98	20.90	
Breast	637	(25.14)	33	5.18		84	13.19	
Colorectum	266	(10.50)	18	6.77		42	15.79	
Esophagus	86	(3.39)	11	12.79		25	29.07	
Liver	110	(4.34)	8	7.27		19	17.27	
Stomach	200	(7.89)	24	12.00		46	23.00	
Others	766	(30.23)	49	6.40		97	12.66	
Cancer stage					*0.181*			*0.659*
I	453	17.88	26	5.74		75	16.56	
II	476	18.78	34	7.14		71	14.92	
III	402	15.86	29	7.21		65	16.17	
IV	295	11.64	20	6.78		42	14.24	
Unclear	908	35.83	84	9.25		158	17.40	
Residency					<0.001			<0.001
Urban	1737	(68.55)	89	5.12		188	10.82	
Rural	797	(31.45)	104	13.05		223	27.98	
Region					<0.001			<0.001
Eastern	370	(14.60)	11	2.97		28	7.57	
Central	1088	(42.94)	108	9.93		207	19.03	
Western	1076	(42.46)	74	6.88		176	16.36	
Insurance					<0.001			<0.001
BMIUE	1210	(47.75)	37	3.06		102	8.43	
BMIUR	335	(13.22)	25	7.46		46	13.73	
NCMS	789	(31.14)	104	13.18		223	28.26	
Others	200	(7.89)	27	13.50		40	20.00	
Household income					<0.001			<0.001
Quintile 1 (Bottom 20%)	508	(20.05)	132	25.98		241	47.44	
Quintile 2	507	(20.01)	30	5.92		80	15.78	
Quintile 3	506	(19.97)	15	2.96		47	9.29	
Quintile 4	505	(19.93)	12	2.38		27	5.35	
Quintile 5 (Top 20%)	508	(20.05)	4	0.79		16	3.15	

Note: *: χ^2 tests; BMIUE – Basic Medical Insurance for Urban Employees; BMIUR: Basic Medical Insurance for Urban Residents; NCMS – Rural New Cooperative Medical Scheme

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Incidence of household impoverishment

In 2015, China reported 3.95 million new cases of cancer: 40% from rural. Almost half (48%) were reported from the eastern zone (Supplementary Table S5).

Prior to cancer treatment, 0.10% and 0.49% of the households were impoverished according to the Chinese poverty line and the global poverty line, respectively. These figures increased to 5.89% and 12.94%, respectively, after cancer treatment (Table 2, Figure 1, Figure 2).

There was an increase of 5.79% households living in poverty after cancer treatment according to the Chinese poverty line. This amounted to 220,978 households. These figures increased to 12.45% and 475,333 households using the global poverty line. The chance of falling into poverty after cancer treatment in rural residents was almost three times of those living in an urban community. Those living in the less developed western and central regions were also two or three times more likely to experience household impoverishment resulting from cancer treatment compared with their more developed eastern counterparts. Rural households and those living in the central region had the biggest increase in impoverishment resulting from cancer treatment (Table 2).

9

Table 2. Household impoverishment induced by cancer treatment

Households	Percentage (number) of households below CPL US$1.2				Percentage (number) of households below WBPL US$1.9			
	Pre-treatment	Post-treatment	Pre-post difference	Estimates of impoverishment induced by cancer treatment in China	Pre-treatment	Post-treatment	Pre-post difference	Estimates of impoverishment induced by cancer treatment in China
Total	0.10 (4)	5.89 (193)	5.79 (189)	5.79(220978)	0.49 (20)	12.94 (411)	12.45 (391)	12.45(475333)
Rural	0.00 (0)	13.05 (104)	13.05 (104)		1.76 (14)	27.98 (223)	26.22 (209)	
Urban	0.23 (4)	5.12 (89)	4.89 (85)		0.35 (6)	10.82 (188)	10.48 (182)	
Eastern	0.00 (0)	2.97 (11)	2.97 (11)	2.97(53989)	0.00 (0)	7.57 (28)	7.57 (28)	7.57(137609)
Central	0.28 (3)	9.93 (108)	9.65 (105)	9.65(104936)	1.10 (12)	19.03 (207)	17.93 (195)	17.93(194973)
Western	0.09 (1)	6.88 (74)	6.79 (73)	6.79(62054)	0.74 (8)	16.36 (176)	15.62 (168)	15.62(142750)

10

Older patients were more likely to experience post-treatment household impoverishment than their younger counterparts ($p<0.001$). Peasants and those who received lower levels of education were more likely to be impoverished than others ($p<0.001$). Higher incidence of post-treatment household impoverishment was found in the respondents with lung, esophagus, and stomach cancers ($p<0.001$). There existed significant regional and wealth-related disparities in incidence of post-treatment household impoverishment. The patients who lived in the less developed central and western regions, had a rural residency, and enrolled with the less generous NCMS had a higher incidence of post-treatment household impoverishment than others ($p<0.001$). The lowest quintile of income group had 25.98% incidence of post-treatment household impoverishment, compared with less than 6% incidence of the other income groups ($p<0.001$). No significant differences were found in incidence of post-treatment household impoverishment across gender, marital status, and stages of cancer (Table 1).

Socioeconomic inequalities in household impoverishment

The households with the lowest quintile of income were hardest hit by cancer treatment, with 25.39% households falling into poverty under the Chinese line as a result of cancer treatment compared with 44.49% under the global poverty line. These figures were at least four times higher than those of the households with higher income. Inequalities in financial protection functions of the social health insurance programs were evident. The rural patients enrolled with NCMS had similar levels of incidence of household impoverishment as compared with those without a coverage of any of the social health insurance programs, much higher than those covered by the two urban insurance programs BMIUE and BMIUR (Table 3).

Table 3. Inequality in household impoverishment induced by cancer treatment

Characteristics of cancer patients	Percentage (number) of households below CPL US$1.2			Percentage (number) of households below WBPL US$1.9		
	Pre-treatment	Post-treatment	Pre-post difference	Pre-treatment	Post-treatment	Pre-post difference
Health insurance						
BMIUE	0.17 (2)	3.06 (37)	2.89 (35)	0.25 (3)	8.43 (102)	8.18 (99)
BMIUR	0.60 (2)	7.46 (25)	6.87 (23)	0.60 (2)	13.73 (46)	13.13 (44)
NCMS	0.00 (0)	13.18 (104)	13.18 (104)	1.77 (14)	28.26 (223)	26.49 (209)
Others	0.00(0)	13.50 (27)	13.50(27)	0.50(1)	20.00(40)	19.50 (39)
Household income						
Quintile 1 (Bottom 20%)	0.59 (3)	25.98 (132)	25.39 (129)	2.95 (15)	47.44 (241)	44.49 (226)
Quintile 2	0.20 (1)	5.92 (30)	5.72 (29)	0.99 (5)	15.78 (80)	14.79 (75)
Quintile 3	0.00 (0)	2.96 (15)	2.96 (15)	0.00 (0)	9.29 (47)	9.29 (47)
Quintile 4	0.00 (0)	2.38 (12)	2.38 (12)	0.00 (0)	5.35 (27)	5.35 (27)
Quintile 5 (Top 20%)	0.00 (0)	0.79 (4)	0.79 (4)	0.00 (0)	3.15 (16)	3.15 (16)

11

The logistic regression model showed that the incidence of post-treatment household impoverishment was associated with age, site of cancer, region, social health insurance, and household income after adjustment for variations in other variables. The incidence of post-treatment household impoverishment increased with age. The patients with breast cancer had lower odds (AOR=0.538, p=0.014) of experiencing post-treatment household impoverishment than those with lung cancer. The odds of the households in the central region (AOR=2.619, p=0.006) experiencing post-treatment household impoverishment more than doubled that in the most developed eastern region. Significant lower odds (p<0.001) of post-treatment household impoverishment were found in the households with higher income compared with those in the lowest quintile of income group. The patients without a coverage of any of the three social health insurance had higher odds (AOR=1.880, p=0.040) of experiencing post-treatment household impoverishment than those enrolled with BMIUE (Table 4). Further analyses indicated that the regional effect had limited interactions, if any, with the effect of urban-rural residency. The correlation between regional zones and urban-rural residency was weak (<0.21) as indicated by the ecoefficiencies of contingency, phi and Cramer's v, albeit a statistically significant difference in χ^2 test (Supplementary Table S3). No significant multicollinearity was identified in the multivariate modelling (Supplementary Table S4). Reginal differences in post-treatment household impoverishment remained in the sample excluding rural participants (Supplementary Table S6).

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Table 4. Logistic regression analysis on predictors of the incidence of post-treatment impoverishment in cancer patients

Characteristics of cancer patients	Crude Odds Ratio (95%CI)	p	Adjusted Odds Ratio (95%CI)*	p
Age (years)				
≤49	1 (reference)		1 (reference)	
50-69	2.544 (1.625-3.981)	<0.001	2.666 (1.659-4.285)	<0.001
≥70	2.996 (1.805-4.974)	<0.001	4.187 (2.400-7.305)	<0.001
Educational attainment				
≤ Junior high school	1 (reference)		1 (reference)	
Senior high school	0.463 (0.312-0.686)	<0.001	0.987 (0.637-1.530)	0.955
≥ University	0.192 (0.106-0.349)	<0.001	1.166 (0.572-2.376)	0.673
Occupation				
Public employee	1 (reference)		1 (reference)	
Commercial employee	1.117 (0.475-2.631)	0.799	0.731 (0.287-1.864)	0.511
Peasant	4.837 (2.496-9.373)	<0.001	0.818 (0.341-1.964)	0.653
Others	1.153 (0.579-2.297)	0.685	0.597 (0.271-1.316)	0.201
Site of cancer				
Lung	1 (reference)	0.002	1 (reference)	
Breast	0.458 (0.290-0.723)	0.001	0.538 (0.328-0.882)	0.014
Colorectum	0.608 (0.347-1.066)	0.082	0.624 (0.342-1.140)	0.125
Esophagus	1.229 (0.612-2.469)	0.562	0.703 (0.328-1.504)	0.363
Liver	0.657 (0.302-1.430)	0.290	0.830 (0.362-1.903)	0.660
Stomach	1.143 (0.681-1.917)	0.613	0.818 (0.463-1.444)	0.488
Others	0.573 (0.379-0.865)	0.008	0.513 (0.324-0.814)	0.005
Residency				
Urban	1 (reference)		1 (reference)	
Rural	2.779 (2.066-3.738)	<0.001	0.993 (0.692-1.425)	0.970
Region				
Eastern	1 (reference)		1 (reference)	
Central	3.597 (1.912-6.767)	<0.001	2.619 (1.317-5.206)	0.006
Western	2.410 (1.265-4.593)	0.007	1.535 (0.766-3.076)	0.227
Health insurance				
BMIUE	1 (reference)		1 (reference)	
BMIUR	2.557 (1.516-4.312)	<0.001	1.225 (0.683-2.195)	0.496
NCMS	4.813 (3.269-7.087)	<0.001	1.355 (0.827-2.219)	0.228
Others	4.948 (2.938-8.332)	<0.001	1.880 (1.030-3.431)	0.040
Household income				
Quintile 1 (Bottom 20%)	1 (reference)		1 (reference)	
Quintile 2	0.179 (0.118-0.272)	<0.001	0.187 (0.121-0.288)	<0.001
Quintile 3	0.087 (0.050-0.151)	<0.001	0.094 (0.052-0.171)	<0.001
Quintile 4	0.069 (0.038-0.127)	<0.001	0.072 (0.037-0.142)	<0.001
Quintile 5 (Top 20%)	0.023 (0.008-0.062)	<0.001	0.024 (0.008-0.070)	<0.001

Note:* R^2 of Cox & Snell=0.104；R^2 of Nagelkerke=0.249；R^2 of McFadden=0.203

The median consumption gap accumulated by the impoverished households post cancer treatment reached US$128 per capita per year underneath the CPL and US$212 per capita per year underneath the WBPL, respectively. These amounted to a total of US$31 million (under CPL) and US$115 million (under WBPL) needed to avoid household impoverishment induced by cancer treatment. The impoverished households with the lowest quintile of income also accumulated twice or tripled consumption gaps

13

underneath the poverty line in comparison with their wealthiest counterpart (Supplementary Table S7).

Discussion

This study presents new evidence on household impoverishment induced by cancer treatment in China. About 5.79% of households became impoverished according to the CPL after paying for cancer treatment out of pocket. This figure would increase to 12.45% using the WBPL. Such an incidence appears to be low compared with findings of studies conducted in some other developing countries [11]. The interpretation of the comparative results needs to be cautious. In this study and others undertaken in China [30], indirect costs associated with medical services such as transportation, foods, and out-of-hospital accommodations were not included in the estimation of costs for cancer treatment. This may have deflated the real financial burden of cancer treatment in China.

The social health insurance programs have limited effects on preventing household impoverishment induced by cancer treatment. Although patients without a coverage of any of the three social health insurance programs are more likely to experience post-treatment household impoverishment than those enrolled with BMIUE, significant increases in household impoverishment after cancer treatment occurred in enrollees of all the three insurance programs. Patients covered by NCMS appear to have the same chance of falling into poverty as those without coverage of any of the social health insurance programs. This coincides with the urban-rural disparities in China: NCMS is designed for rural residents who usually have lower income compared with their urban counterparts [31]. Previous studies found that funding available for NCMS enrollees is only about half of that for BMIUE enrollees [32]. Empirical evidence shows that public financing is effective in protecting the most vulnerable populations from medical-induced poverty [33-35]. However, this requires well targeted investments (the so-called precision poverty alleviation) [36]. This study estimates that at least 31 million US dollars will be needed annually to alleviate the impoverishment induced by cancer treatment according to the CPL, or 115 million US dollars according to the WBPL. Previous studies showed that BMIUE had the highest level of compensation rates and the lowest OOP requirements in comparison with the other two schemes [23, 37]. The average payments from the insurance programs for hospital admitted patients were estimated to be around 68% for BMIUE, 48% for BMIUR and 44% for NCMS in 2011 [23]. The eastern region offered a higher level of compensations. In Suzhou, for example, 73%, 71% and 56% of hospital charges were covered by BMIUE, BMIUR and NCMS, respectively in 2014 [37]. Under-the-table user fees were nominal, if ever existed, due to strict regulations.

Socioeconomic inequality in household impoverishment resulting from cancer treatment in China deserves increasing policy attention. This study found that inequalities exist from a range of perspectives: (1) Households with the lowest quintile of income stand at least four times higher chance of falling into poverty after cancer treatment than the richer ones: more than one quarter of them became impoverished under the Chinese poverty line or almost 45% under the global poverty line. These results are consistent with findings of other studies [38-40]. (2) Rural households have

14

tripled incidence of impoverishment induced by cancer treatment compared with the urban ones. The urban-rural inequality is likely to be a result of income disparities [31] and disparities in primary care services [41, 42]. The urban-rural difference in incidence of post-treatment household impoverishment disappeared after adjustment for variations in other variables. (3) Like findings of previous studies [11], older people were found in this study to suffer more from household impoverishment as a result of cancer treatment. (4) Significant regional disparities exist. Although it is certain that the most developed eastern region is better off, the central developing region suffers more than the poorest western region. In 2015, disposable income of the central region averaged at US$2961 per capita, compared with US$4531 in the eastern and US$2708 in the western region [43]. However, the national government of China has provided significantly more financial subsidies to the western region than to the central region. Previous studies also show that patients from the central region are more likely to seek more expensive medical services compared with their western counterparts due to higher financial capability, convenience of transportation and better accessibility to high medical technologies [44].

It is important to note that accessibility to healthcare services can be seriously jeopodized by low household income especially in a system that requires high proportions of out of pocket payments [45]. This study showed an absence of pre-treatment household impoverishment for rural residents. Empirical evidence shows that some households with low income are likely to forfeit expensive medical care including cancer treatment to avoid impoverishment [46]. The actual scale of household impoverishment would be higher should all cancer cases are treated in line with relevant clinical guidelines. Indeed, low household income may suppress the spending of medical care despite wide coverage of health insurance according to the findings of this study.

Findings of this study have some policy implications. The current health insurance programs in China are highly fragmented, which is, at least partly, a result of the urban-rural dual structure. A better coordinated effort is needed to address the inequality in household impoverishment induced by cancer treatment. This can start from a national central cancer registry system and share of insurance claim data given that the national government of China has been increasing its investments in social health insurance, health services delivery, and medical assistance (to help poor households to enroll with social health insurance and pay for OOP expenses) programs. However, higher insurance entitlements may stimulate consumer demands, increasing the risk of catastrophic health expenditure. Government investments need to be channeled to those most in need [47]. This may include cross-subsidising mechanisms between urban and rural insurance schemes. Meanwhile, strong cost containment measures need to be taken. The role of primary care in managing cancer patients should be strengthened. Hospital costs should be contained by encouraging evidence-based practices through funding and payment reforms[48].

This study has several limitations. Firstly, data in this study were collected through questionnaire survey, which are subject to recall bias. The sensitivity test indicates that patient estimation of household consumption is significantly higher than that from the

15

caregivers (supplementary Table S1). Secondly, the stratified sampling strategy adopted in this study ensured that the minimal sample size could be met in all of the three regions. However, the more populated eastern region was under-represented. Thirdly, non-medical costs like travel were excluded in this study. The financial sources of household consumption were unknown. Some households were likely to borrow money to pay for the consumptions. Household impoverishment was determined by daily consumption in this study, which is a widely accepted approach. However, we did not examine the source of income for household consumptions. If some households borrowed money or realized assets to pay for daily consumption, this could lead to potential underestimation of household impoverishment. Further studies are needed to examine whether income falls post treatment (people losing their jobs), which categories of consumption are most impacted by cancer treatment spending, and where households are deciding to cut costs.

Conclusion

The financial burden of cancer treatment imposes a significant risk of household impoverishment in China despite an almost universal coverage of social health insurance. The risk falls disproportionally onto the households living with low income. Significant socioeconomic inequalities exist in household impoverishment resulting from cancer treatment. Unbalanced regional development and fragmentation of health insurance programs may have jeopardized the efforts in alleviating poverty induced by medical services.

Abbreviation list

CPL: Chinese poverty line;

WBPL: World Bank poverty line;

OOP: out-of-pocket payment;

BMIUE: basic medical insurance for urban employees;

BMIUR: basic medical insurance for urban resident;

NCMS: rural new cooperative medical scheme

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18

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Ethics approval: The study protocol was approved by the Institutional Review Board of the Cancer Hospital of Chinese Academy of Medical Sciences (Approval No. 15-071/998).

Provenance and peer review: Not commissioned; externally peer reviewed.

Data sharing statement: No additional data are available.

Figure legends

Figure 1

Title: Pen's Parade of impoverished households before and after cancer treatment

Horizontal axis : Cum % of pop, ranked by consumption per capita

Vertical axis: Consumption per capita (US$)

Legends: Blue line: Pre-treatment

　　　　　Red line: Post-treatment

Figure 2

Title: Pen's Parade of impoverished households before and after cancer treatment (in view of the bottom 20%)

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Horizontal axis : Cum % of pop, ranked by consumption per capita

Vertical axis: Consumption per capita (US$)

Legends: Blue line: Pre-treatment

　　　　　Red line: Post-treatment

　　　　　--- : China's poverty line

　　　　　········ : Global poverty line
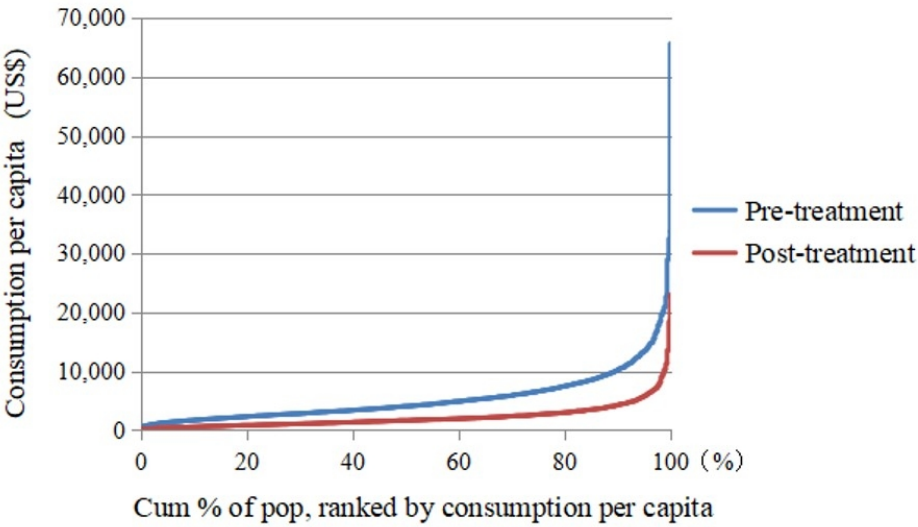
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Figure 1. Pen's Parade of impoverished households before and after cancer treatment

254x190mm (96 x 96 DPI)

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Figure 2. Pen's Parade of impoverished households before and after cancer treatment (in view of the bottom 20%)

254x190mm (96 x 96 DPI)

Supplementary File

Table S1. Household consumption per capita pre- and post-treatment by respondents (patients vs caregivers)

	Sample size N (%)		Consumption per capita pre-treatment					Consumption per capita post-treatment				
	Patients N (%)	Caregivers N (%)	Overall Median (P25, P75)	Patients Median (P25, P75)	Caregivers Median (P25, P75)	χ^2	P	Overall Median (P25, P75)	Patients Median (P25, P75)	Caregivers Median (P25, P75)	χ^2	P
Total	1334 (52.6%)	1200 (47.4%)	4014 (2601,6538)	4431 (2890,7064)	3506 (2316,6021)	39.70	0.00	1606 (902,2622)	1782 (1020,3024)	1445 (813,2200)	40.82	0.00
Residency												
Urban	965 (55.6%)	772 (44.4%)	4359 (2810,6952)	4774 (3067,7432)	3934 (2569,6422)	18.29	0.00	1846 (1124,2946)	2042 (1284,3436)	1670 (1017,2438)	31.19	0.00
Rural	369 (46.3%)	428 (53.7%)	3350 (2197,5374)	3746 (2447,5748)	2953 (2007,5139)	18.45	0.00	1069 (642,1789)	1190 (692,1959)	1029 (618,1684)	4.68	0.03
Region												
Eastern	293 (79.2%)	77 (20.8%)	6007 (4041,9280)	6061 (4172,9505)	5460 (3547,9152)	0.26	0.61	2456 (1400,4174)	2729 (1461,4292)	1827 (1127,2826)	5.31	0.02
Central	589 (54.1%)	499 (45.9%)	3615 (2328,6128)	3853 (2515,6255)	3340 (2143,6021)	6.53	0.01	1445 (803,2155)	1498 (835,2256)	1365 (803,1991)	4.11	0.04
Western	452 (42%)	624 (58%)	3744 (2531,6021)	4173 (2912,6506)	3465 (2360,5534)	16.12	0.00	1646 (913,2613)	1906 (1109,3183)	1445 (816,2284)	24.32	0.00
Insurance												
BMIUE	689 (56.9%)	521 (43.1%)	4629 (2935,7172)	4957 (3211,7626)	4137 (2649,6543)	9.83	0.00	2007 (1284,3199)	2208 (1440,3546)	1782 (1070,2569)	25.25	0.00
BMIUR	174 (51.9%)	161 (48.1%)	4014 (2703,6636)	3988 (2649,6636)	4014 (2810,6636)	0.00	0.97	1606 (963,2529)	1606 (963,2729)	1517 (978,2380)	0.57	0.45
NCMS	366 (46.4%)	423 (53.6%)	3333 (2188,5374)	3746 (2447,5994)	2904 (2007,5137)	19.25	0.00	1073 (642,1798)	1189 (690,1965)	1025 (615,1686)	3.84	0.05
Others	105 (52.5%)	95 (47.5%)	3698 (2418,6497)	4957 (3152,7430)	3042 (1741,4785)	23.18	0.00	1565 (803,2376)	1813 (835,3479)	1217 (679,1782)	1.28	0.26
Household income												
Quintile 1 (Bottom 20%)	228 (44.9%)	280 (55.1%)	2721 (1735,4226)	3191 (1950,4717)	2437 (1658,3547)	10.89	0.00	717 (438,1181)	787 (479,1191)	700 (428,1177)	0.96	0.33
Quintile 2	255 (50.3%)	252 (49.7%)	3118 (2167,4710)	3372 (2408,4710)	2893 (1992,4696)	4.00	0.05	1204 (865,1766)	1284 (867,1873)	1134 (863,1625)	5.13	0.02
Quintile 3	272 (53.8%)	234 (46.2%)	3864 (2649,6290)	4108 (2732,6374)	3567 (2569,6116)	2.30	0.13	1646 (1127,2288)	1711 (1199,2408)	1606 (1112,2143)	0.81	0.37
Quintile 4	287 (56.8%)	218 (43.2%)	4817 (3235,7474)	5057 (3527,7787)	4469 (2855,7084)	3.04	0.08	2141 (1373,2950)	2256 (1606,3372)	1833 (1188,2574)	8.71	0.00
Quintile 5 (Top 20%)	292 (57.5%)	216 (42.5%)	6422 (4541,9500)	6816 (5029,9966)	5871 (3948,8590)	10.88	0.00	3211 (1999,4926)	3612 (2408,5683)	2477 (1816,4034)	31.51	0.00

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Table S2. Items measuring household income, consumption and out of pocket payment for cancer treatment

Household income
Covered
Wage
Non-wage: return on capital investments, dividends, interests, governmental subsidies
Self-employed income
Property income
Supportive income: pension paid to parents by children
Gift
Not-covered
Personal secret income of unknown origin, not recorded, tax evasion, undeclared
Household Consumption
Covered
Foods
Clothing
Daily necessities
Transportation
Communication
Housing mortgage or rent
Utility: Water, electricity and gas
Education
Medical care (drugs, services and supplies)
Insurance
Cultural activities
Entertainment activities
Not-covered
Capital investments and repairments
Other profit generating investment activities
Out of pocket payments for cancer treatment
Covered
Hospital services
Medicine
Not-covered
Insurance reimbursement for medical expenditure
Transportation
Out of hospital accommodations
Meals
Nutrients
Informal caregivers

Table S3. Correlation between region and urban/rural residency in respondents

	Eastern		Central		Western		Pearson χ²*	Contingency Coefficient*	Phi Coefficient*	Cramer's V*	Lambda*
	N	(%)	N	(%)	N	(%)					
Total	370	(100.00)	1088	(100.00)	1076	(100.00)	108.389	0.203	0.207	0.207	0.099
Urban	256	(69.19)	857	(78.77)	624	(57.99)					
Rural	114	(30.81)	231	(21.23)	452	(42.01)					

Note: *P<0. 001

Table S4. Collinearity diagnosis results

	Tolerance	VIF
Age (years)	0.87	1.15
Educational attainment	0.64	1.56
Occupation	0.94	1.07
Site of cancer	0.95	1.05
Residency	0.50	2.00
Region	0.90	1.11
Health insurance	0.50	2.00
Household income	0.65	1.53

Table S5. New cases of cancer recorded in China, 2015

Location	No. population (100,000)*	Incidence (per 100,000 population)**	Number (percentage) of cases
Total	13,746	288	3,953,957 (100%)
Residency			
Rural	6,035	267	1,608,221 (40%)
Urban	7,712	311	2,394,606 (60%)
Region			
Eastern	5,690	319	1,817,816 (48%)
Central	4,305	253	1,087,415 (28%)
Western	3,751	244	913,896 (24%)

Source of data: * National Bureau of Statistics of China. China Statistical Yearbook 2015. China Statistics Press;

** National Cancer Center. China Cancer Registry Annual Report 2018. People's Medical Publishing House

Table S6. Regional differences in urban household impoverishment post cancer treatment

	Sample size	Household consumption below CPL US$1.2		Household consumption below WBPL US$1.9		χ^2	P
	N (%)	number	%	number	%		
Total	1737 (100.00)	89	5.1	188	10.8	15.784	0.000
Eastern	256 (14.74)	4	1.6	10	3.9		
Central	857 (49.34)	61	7.1	121	14.1		
Western	624 (35.92)	24	3.8	57	9.1		

Table S7. Accumulated consumption gap post cancer treatment in impoverished households in China

Characteristics of cancer patients	Total (median) Annual US$ gap per capita		Estimates of impoverishment induced by cancer treatment in China	
	Households below China's poverty line US$1.2	Households below global poverty line US$1.9	Households below China's poverty line US$1.2	Households below global poverty line US$1.9
Total	27,488 (128)	91,081 (212)	31,170,395	115,238,459
Region				
East	1,266 (71)	6,108 (220)	6,221,542	30,010,513
Midland	15,616 (134)	48,746 (212)	15,777,767	52,298,712
West	10,605 (122)	36,226 (182)	9,171,086	32,929,233
Residency				
Rural	15179 (127)	48080 (212)		
Urban	12308 (128)	43001 (212)		
Health insurance				
UEBMI	5,699 (128)	21,245 (172)		
URBMI	2,589 (91)	10,201 (255)		
NCMS	15,179 (127)	48,080 (212)		
Others	4,019 (148)	11,555 (292)		
Household income				
Quintile 1 (Bottom 20%)	19,020 (132)	58,289 (256)		
Quintile 2	4,451 (112)	14,997 (185)		
Quintile 3	1,698 (82)	8,713 (148)		
Quintile 4	2,110 (150)	6,307 (158)		
Quintile 5 (Top 20%)	209 (44)	2,774 (153)		